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DISRUPTIVE TECHNOLOGIES IN PUBLIC PROCUREMENT

JANUARY 2021

Governance – Procurement
Equitable Growth, Finance & Institutions

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ABBREVIATIONS

AI	Artificial Intelligence
AM	Additive Manufacturing
API	Application Programming Interface
BCT	Blockchain Technology
CPV	Common Procurement Vocabulary
DT	Disruptive Technology
ERP	Enterprise Resource Planning
ETL	Extract, Transform, Lead
EU	European Union
FCV	Fragility, Conflict, and Violence
GDP	Global Domestic Product
GDPR	General Data Protection Regulation
GIS	Geographic Information System
GPS	Global Positioning System
HIC	High-Income Country
IaaS	Infrastructure as a Service
IoT	Internet of Things
IP	Internet Protocol
KPI	Key Performance Indicator
LIC	Low-Income Country
LPWAN	Low-Power Wide Area Network
MDM	Master Data Management
MIC	Middle-Income Country
NA	Not Applicable
NLP	Natural Language Processing
OCR	Optical Character Recognition
PaaS	Platform as a Service
POC	Proof of Concept
PTP	Procure to Pay (sometimes referred to as P2P)
RFI	Requests for Information
RFID	Radio Frequency Identification
RFP	Request for Proposal
RFQ	Request for Quote
ROI	Return on Investment
RPA	Robotic Process Automation
SaaS	Software as a Service
SLA	Service-Level Agreement
SME	Small and Medium-Sized Enterprise
STC	Source to Contract (sometimes referred to as S2C)
STL	(File Format) Abbreviation of "stereolithography"
TCO	Total Cost of Ownership
TVO	Total Value of Ownership
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
VFM	Value for Money
XaaS	Everything as a Service

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I. EXECUTIVE SUMMARY

This study presents the conclusions drawn from research on a selection of technologies identified as "disruptive" that could potentially be useful to public procurement. The report includes several case studies of experience gained from the deployment of these technologies around the world, complemented by desk research, allowing for an assessment of the technologies' maturity level and their capacity to create value in the public procurement process. The preconditions required to adopt the new systems and the potential interaction between them are also discussed.

1. CONTEXT AND OBJECTIVES OF THE STUDY

1. **Context and assumptions**
   The motivation behind this study was the shared observation that the performance of public procurement is a major concern for policy makers globally. The strong interest in public procurement can be explained by the following elements:

- The quality of purchases of public services and infrastructure has a critical impact on the economic environment in general. Efficient and appropriate public procurement facilitates trade and promotes economic growth.
- More immediately, procurement departments often transfer public funds to local business actors by awarding contracts and thus take part in the creation of jobs and economic development.
- Public procurement also stimulates innovation through competitive tenders, often leading to better training for the local workforce and to higher employment rates.
- For several years, the integrity, transparency, and efficiency of public spending has increasingly become a focus of wider public attention and concern.

There is a clear recognition that entirely new technologies have recently emerged that are transforming almost all sectors of the economy. These new technologies will radically change the way public organizations around the world conduct their purchases, and these fundamental changes will likely benefit not only public buyers but also suppliers and citizens. Moreover, most public procurement actors are by now familiar with the use of technology to improve the transparency, efficiency, and performance of public procurement systems. Typically, this technology has been translated into the creation of electronic government procurement (e-GP) systems to share procurement information and support the processes along the procurement cycle. **The use of these new, "disruptive" technologies (DTs) in public procurement has significant potential to strengthen the strategic function of public purchases within governments and society at large.**

The use of certain new technologies has become particularly crucial during the COVID-19 crisis. For those procurement organizations previously not ready to introduce digital solutions, the

crisis turned out to be a major transformation booster. Procurement professionals have shown great resilience, employing both extremely simple and also highly complex technologies to support procurement officers in responding to the crisis. For example, hospitals in France and the United States have used 3D-printed nasal test swabs or adaptors for ventilators to tackle supply shortages, while an increasing number of requests for proposals (RFPs) and quotes have been released and collected digitally.

2. **Objectives of the study**

This report is intended for the World Bank and its clients. It is designed to help governments and task teams in designing and implementing procurement reforms and embedding innovative, disruptive, and other new technologies. More precisely, the purpose is:

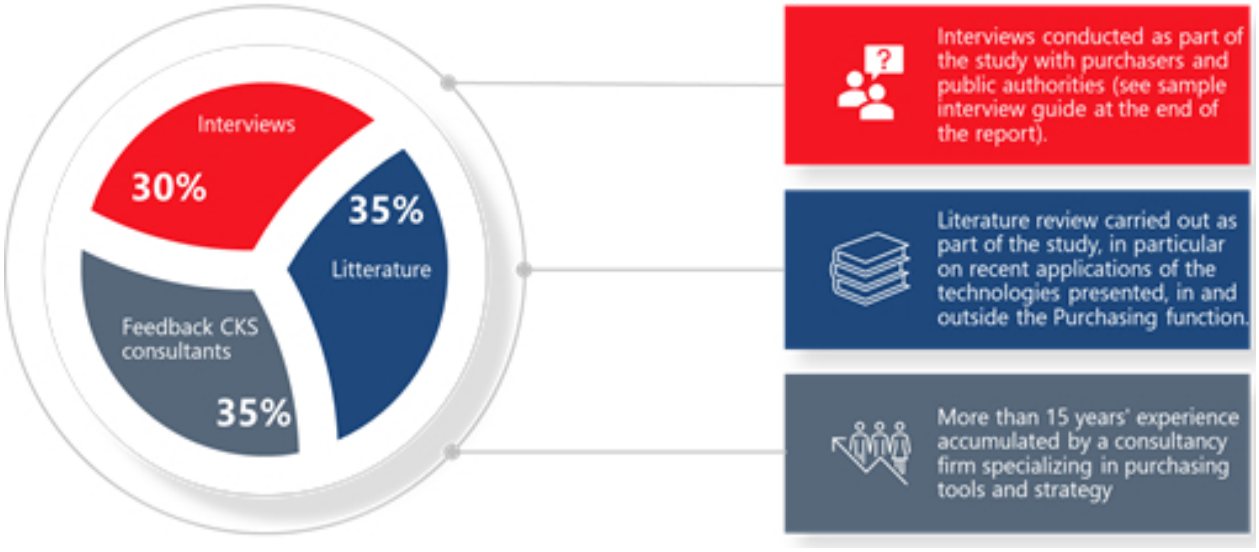
- To offer a review of existing technological solutions available for short- or medium-term implementation
- To shed light on the current application of DTs
- To provide guidelines to World Bank client countries to support the potential implementation of DTs in their public procurement process
- To highlight the risks and challenges involved in introducing these technologies

2. CONTENT OF THE STUDY

To address the objectives laid out in this report, a number of technologies with the highest actual or potential impact on the public procurement process have been identified. Each technological impact has been modelized and assessed based on indicators of potential value added, and each one has been contrasted against the possible risks and challenges that the technology might induce. For each technical or nontechnical issue, mitigation measures are provided, and the report also provides a lengthy list of the prerequisites needed for the successful implementation of the various new systems.

Additionally, some actual projects have been analyzed and their results comprehensively described. The legal options and macro steps to follow for the acquisition of these technological tools are discussed, and finally, a non-exhaustive list of suppliers operating in various technological fields is presented at the end of the document.

In the body of the study, the scores attributed to the different technologies (maturity, maturity for the purchasing function, driving forces, benefits, risks) are based on a review of specialized literature, interviews with public procurement professionals, and the experience from some projects in different countries.



3. SELECTED DISRUPTIVE TECHNOLOGIES

1. **Focus on the concept : "Disruptive technology"**

Disruptive technology (DT) became a mainstream theory in the mid-1990s before gaining prominence in everyday life at the beginning of the 21st century. At the time, the recent spread of the internet and mobile networks was beginning to transform a large number of business practices and promised considerable productivity gains. In reality, these new technologies took time to take hold in companies and to produce the expected results. The most recent developments, such as big data technologies or blockchain, are still largely under-exploited within the real economy. What has become clear is that the concrete adoption of a technology by an economic sector depends not only on its intrinsic quality or its maturity, but also on the maturity of the economic sector itself: Are the procedures sufficiently clear and able to be shared to accommodate automation tools? Are the data sufficiently available and abundant to feed disruptive analysis models? Are existing tools compatible with the introduction of breakthrough technologies?

2. **Selection of DTs**

Within the framework of this study, nine technologies that have actual or potential impacts on public procurement have been identified:

- **Cloud Computing and "XaaS":**
  The acronym XaaS stands for "everything-as-a-service" and refers to the different models of cloud computing "as a service." It was created following the emergence of many cloud computing services, such software as a service (SaaS), platforms as a service (PaaS), or infrastructure as a service (IaaS). These three models of cloud services are those listed in the original document defining cloud computing published by the National Institute of Standards and Technology (NIST) in the United States.[1]
- **Big Data and Analytics:**
  The term "big data" was coined in October 1997, according to the Association for Computing Machinery, and was found in the Digital Library archive in scientific articles describing the technological challenges of visualizing "big data sets."[2] It describes the quantitative explosion of digital data, which forced researchers to find new ways of seeing and analyzing the world. This has meant discovering new orders of magnitude in the capture, retrieval, sharing, storage, analysis, and presentation of data. Thus, the term "big data" refers to the storing of huge amounts of information on a numerical basis.
- **Artificial Intelligence:**
  Artificial intelligence (AI) refers to "an application capable of processing tasks that are currently performed more satisfactorily by human beings insofar as they involve high-level mental processes such as perceptual learning, memory organization and critical thinking."[3] This is how the American scientist Marvin Lee Minsky, considered to be the father of AI, defines the concept. Currently, the most widespread use of AI algorithms can be found in natural language processing (NLP) or facial recognition.
- **Robotic Process Automation:**
  Robotic process automation (RPA) is a technology designed for automating repetitive tasks. The software robot connects to an application to manipulate data, perform calculations, communicate

[1] P. Mell and T. Grance, "The NIST Definition of Cloud Computing: Recommendations of the National Institute of Standards and Technology (Washington, DC: U.S. Department of Commerce, 2011), https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf.

[2] G. Press, "A Very Short History of Big Data," Forbes, May 9, 2013, https://www.forbes.com/sites/gilpress/2013/05/09/a-very-short-history-of-big-data/?sh=7e39c8f065a1.

[3] AI for Humanity, "What is Artificial Intelligence? Villani Mission on Artificial Intelligence" (Paris: AI for Humanity, 2018), (https://www.aiforhumanity.fr/pdfs/MissionVillani_WhatisAI_ENG(1)VF.pdf.

with other digital systems or carry out various actions. For example, it may perform database inquiries, maintain records, or process transactions. This technology is often based on the use of AI software or machine learning, which makes "software robots" capable of imitating a human worker.

- **Blockchain:**
  Blockchain is a cryptographically secured distributed database technology for storing and transmitting information. Each record in the database is called a block and contains such details as the transaction date and link to the previous block. It has mainly been popularized through cryptocurrencies such as Bitcoin. However, blockchain technology (BCT) can support any type of digitized information, preferably transactional data. Thus, it can be used in the field of big data, especially to increase data security or quality.
- **Geographic Information Systems and Geotagging:**
  A geographic information system (GIS) is an information program designed to collect, store, process, analyze, manage, and present all types of spatial and geographic data. GIS-related applications are tools that allow users to create interactive inquiries, analyze spatial information, modify and edit data through maps, and respond to that data cartographically.
- **Internet of Things and Remote Sensors:**
  The term "Internet of Things" (IoT) first appeared in 1999 in a speech by Kevin Ashton, a British engineer.[4] It is used to refer to a system in which physical objects, often remote sensors, are connected to the internet and are capable of creating and transmitting data in order to create value for its users through various services (aggregation, analytics, and so on).
- **Drones:**
  Drones are unmanned aerial vehicles (UAVs) with automatic or remote-controlled piloting for civil or military use. They can be particularly utilized to collect visual data or to transport goods to or from isolated areas.
- **3D Printing (Additive Manufacturing):**
  3D printing, or additive manufacturing, groups together the procedures for manufacturing parts in volume through adding or agglomerating material by stacking successive layers. 3D printing makes it possible to produce real objects. A designer draws the 3D object using a computer-aided design (CAD) tool. The 3D file obtained is processed by specific software that organizes the slicing of the different layers required to produce the part. The slicing is sent to the 3D printer, which deposits or solidifies the material layer by layer until the final part is obtained.

4. MATURITY OF THE TECHNOLOGIES

1. **Maturity levels of each technology**

For each of these technologies, the following table presents:

- The maturity level of the technology itself, which means its ability to respond to a wide range of needs on a long-term basis
- The maturity level of each technology regarding specific public procurement business needs

These levels of maturity have been estimated by looking at the distribution of the corresponding tools within companies/purchasing departments around the world and by comparing the technical potential of each technology and its current use within the business community.

2. **Differences between groups of countries**

Although these maturity levels have been established by considering the business use

[4] K. Ashton, "That 'Internet of Things' Thing," RFID Journal, June 22, 2009, http://www.itrco.jp/libraries/RFIDjournal-That%20Internet%20of%20Things%20Thing.pdf.

of the technologies globally, it should be noted that in reality, these levels of technology diffusion differ greatly between regions and countries. The ability of a European procurement department to adopt big data analytics tools is obviously not the same as it is in countries where data sharing is not widespread or in regions with poor internet connections.

Technology	Level of Maturity	
	Maturity of the Technology	Maturity for Public Procurement
Cloud & XaaS	Very High	High
Big Data & Analytics	High	Medium
Artificial Intelligence	Medium	Medium
RPA	High	Medium
Blockchain	Low	Low
Geotagging & GIS	High	Low
IoT	Medium	Low
Drones	Medium	Low
3D Printing	High	Medium

This is why the conclusions made here pertain to distinct country groups that correspond to the following World Bank classifications:

- Countries affected by fragility, conflict, and violence (FCV) and low-income countries (LICs)
- Middle-income countries (MICs)
- High-income countries (HICs)

All selected technologies are of course not "equally disruptive" in every country. Cloud and SaaS procurement solutions and, to a lesser extent, data analytics are already widespread within the public procurement operations of high-income countries. However, these tools remain quite rare in most FCV countries and LICs, which justifies their consideration in this report.

5. IMPACTS OF THE SELECTED TECHNOLOGIES ON PUBLIC PROCUREMENT

1. **Impacted procedures and steps of public procurement**

The study provides an evaluation of the benefits of each DT on the particular steps of the source-to-contract (STC) process, which is the major public procurement progression, going from the definition of needs to contract execution. Some observations are also provided regarding the impact of tools on the related procure-to-pay (PTP) process, which involves the processing of orders and invoices, management of goods reception, and so on.

Some general conclusions can be drawn when observing the grid of impacts:

- Cloud and XaaS has a potential impact on every step of the process, which is not surprising, given that this technology generally takes the form of mature solutions designed precisely to cover the entire purchasing process.
- Similarly, big data, RPA, and AI have a wide range of potential uses and may affect most procurement-related tasks.
- GIS, IoT, drones, and 3D printing, which are generally used more in specific operational contexts, are above all likely to intervene upstream and downstream of the purchasing consultation, that is, when defining the purchasing strategy and monitoring the execution of the contract.
- Blockchain, the main benefit of which is the secure sharing of information, can have an impact on the tendering process as well as the invoicing and execution follow-up steps.

2. **Synthesis of the value added brought by DTs**

Each technology can add value to the purchasing process in different ways. An assessment of each DT's value for money (VFM) is provided in the table below.

- **Cloud computing and XaaS may:**
  - Help reduce maverick buying by automating the verification of whether a requested item or substitute is covered by existing contracts
  - Help buyers increase direct savings

and eventually add value to purchasing strategies by increasing buyers' bargaining power thanks to shared procurement software and contract renegotiation models

- Improve management of workload and tendering schedules through dynamic data visualization tools for predictive and prescriptive analyses of the procurement workload
- Support the accuracy of decision making by providing correct data and enhancing visibility on spending and supplier data

- **Big data and analytics may:**
  - Contribute to enhanced spending management by representing spend data by work or consumption unit and enriching existing reports with external sources
  - Facilitate sourcing, evaluation, and negotiation preparations by increasing the capacity to identify best practices and helping to recognize bundling opportunities
- **RPA and AI may:**
  - Automate low value-added tasks in the public tendering and contract execution process, for example, by allowing automated background checks and document review for the supplier onboarding process or by generating draft versions of tendering documents
  - Contribute to enhanced contract management and the automated tracking of contracts used to collect rebates, discounts, and penalties related to service-level agreements (SLAs)
- **Geotagging and GIS may:**
  - Help define purchasing strategies and improve tendering documentation by clarifying requirements upstream of the tendering process, both in nature and volume, for example, through an automated embedding of the spatial data in tendering documents (in particular, requests for quotes [RFQs])
  - Help assess the supplier's performance, prevent undesirable events, and verify the fulfillment of contract objectives
- **Blockchain may:**
  - Lead to a cycle time reduction through improved document flows during the tendering process as a result of simplified approval and signature procedures
  - Offer increased capacity in contract management by securing acceptance reports and automating the document-validation process and application of possible penalties
- **IoT and remote sensors may:**
  - Enhance visibility on equipment usage and on user needs and habits and thus facilitate RFP preparation
  - Foster identification and anticipation of equipment faults and stoppages during execution stages and facilitate the monitoring of SLAs
- **Drones may:**
  - Provide new techniques for the monitoring and management of contract execution by overcoming geographic hurdles and eliminating transport-related costs
- **3D printing may:**
  - Provide new options in deciding whether to "make or buy" and then offer a reliable "purchasing lever" in cases of obsolescence or when items are needed in small batch sizes
  - Eliminate risks and costs related to delivery practices

3. **Compliance benefits and positive externalities**

Some of these technologies are also of great interest to the integrity and transparency of public procurement. Of course, technologies for sharing and securing data are particularly advantageous in this respect. For example, blockchain may provide a clear channel that ensures that all stakeholders behave according

Technology	Value for Money			
	Business	Compliance	Positive Externalities	Average
Cloud & XaaS	Very high	High	Low	High
Big Data	Medium	High	Low	Medium
Data Analytics	High	Low	Medium	High
RPA and Artificial Intelligence	High	Medium	Very Low	Medium
Geotagging & GIS	Medium	Medium	Low	Medium
Blockchain	Low	Very High	Very Low	Medium-Low
Remote sensing and IoT	Medium	Very Low	Medium	Medium-Low
Drones	Low	N/A	High	Medium
3D-Printing	High	N/A	Medium	High

to the relevant legislation during the tendering process by means of smart contracts, which guarantee a secured transmission of bids. Similarly, a comparison of numerous similar bids enabled by data analytics could increase the ability to detect fraudulent behavior among public buyers.

With regard to positive externalities, big data is potentially useful as a way to reduce inequalities in public procurement access by offering all players the same visibility. Furthermore, technologies that make traditional means of transport obsolete, such as drones or 3D printing, can also enable purchasing organizations to contribute to other sustainable development goals, for example, lowering CO_2 emissions.

In conclusion, an estimate of the potential VFM brought by each DT is provided in the following table. These VFM levels are broken down into the three types of benefits—business and compliance benefits and positive externalities—and correspond to the ratings in the balanced scorecards presented in chapter IV.

6. ADOPTION OF THESE TECHNOLOGIES: POTENTIAL RISKS AND IMPLICATIONS

1. **Nontechnical issues**

The work carried out has made it possible to identify obstacles to the adoption of certain technologies. The table below shows the main nontechnical obstacles that could hinder the implementation of the tools analyzed. The criticality levels indicated correspond to the results given in the scorecards in chapter IV.

2. **Technical issues**

Similarly, six technical or operational issues likely to affect technology implementation projects are presented below, with a qualification of the issue's potential impact for each DT and a non-exhaustive list of recommended mitigation measures.

Technology	Importance of the Issue				
	Change Management Difficulty	Negative Externalities	Regulatory Barriers	Maturity / Durability Issue	Average
Cloud & XaaS	Medium	Low	Low	Very Low	Low
Big Data	Low	Very Low	Low	Medium	Low
Data analytics	N/A	N/A	Low	High	Low
Artificial Intelligence & RPA	Medium	Medium	Very Low	Low	Low
Geotagging & GIS	Medium	N/A	Very Low	Low	Low
Blockchain	High	High	Medium	Medium	High
IoT	High	Low	Medium	Medium	Medium
Drones	Very Low	Medium	High	Very Low	Low
3D-Printing	Low	N/A	Low	Mature	Low

Disruptive Technology	Interoperability		Reversibility and Dependency		Complexity and Difficulty in Specifying	
	Importance of the issue	*Good practices to consider*	*Importance of the issue*	*Good practices to consider*	*Importance of the issue*	*Good practices to consider*
Cloud & XaaS	Low	1) Carry out preliminary studies. 2) Establish standards to ensure interoperability among devices, networks, services, and data formats.	High	1) Formalize very clear commitments in the tendering documentation in the event of reversibility/transferability. 2) Internalize part of the maintenance/administration. 3) Avoid proprietary frameworks.	Medium	1) Carry out preliminary studies in order to prioritize needs. 2) Formulate the needs in terms of functionalities and performance rather than in terms of solutions. 3) Use the services of specialized consultants in the strategy preparation, bid evaluation, and implementation phases.
Big Data & Analytics	Low		Medium		Low	
Artificial Intelligence & RPA	Medium		Medium		Medium	
Blockchain	High		High		Medium	
Geotagging & GIS	High		High		High	
IoT	Very High		Very High		High	
Drones	Low		Low		Low	
3D Printing	Low		Low		Very low	
Disruptive Technology	**Risk of budget slippage**		**Scarcity of resource**		**Difficulty of adoption**	
Cloud & XaaS	Medium	1) Start small with pilot projects (POC) and invest progressively according to roll-out plan. 2) Retain project management assistance that is able to find work-around solutions. 3) Favor lump-sum commitments. 4) Strengthen the clauses and the system for monitoring contractual execution and measuring gains.	Medium	1) Include clauses to ensure that skills are made available over the long term. 2) Facilitate access for SMEs, in particular by defining application criteria that do not exclude them unnecessarily. 3) Include in the contracts an obligation to transfer know-how on the administration and first-level maintenance of the technological solution.	Medium	1) Define bid evaluation criteria that are not only "technical." 2) Beware of implementing solutions that are too complicated for users to handle. 3) Conduct a real approach to the impact of technology on the various stakeholders. 4) Involve end users and middle management as early as possible. 5) Participate in user clubs.
Big Data & Analytics	Medium		Medium		Low	
Artificial Intelligence & RPA	High		Medium		Medium	
Blockchain	High		Medium		Medium	
Geotagging & GIS	High		Very high		High	
IoT	High		High		High	
Drones	Low		Low		Medium	
3D Printing	Very Low		Low		Low	

7. PREREQUISITES: TOOLS AND SKILLS REQUIRED FOR SUCCESSFUL ADOPTION

1. Related technologies and materials

An organization wishing to adopt a new system must also ensure that it has the necessary materials and tools, without which the technology would not be able to fully develop its potential. Generally speaking, it is crucial to remember that the introduction of technologies related to big data or AI should be pursued only if a sufficient amount of data are available within the public organization, and above all, only if a culture of data sharing is present.

2. Required skills

People who are likely to interact with a new technology must be willing to use it and able to understand its functionality and operation prior to its effective adoption. In certain cases, this requires significant training of the workforce concerned, which is more difficult for organizations in which people are unfamiliar with the latest technologies.

Furthermore, to acquire and implement certain tools, organizations must ensure that the project team possesses the required technical skills. This is even more important for projects that involve non-standard tools that are meant to meet specific organizational needs.

3. Legal framework

Finally, for the adoption of a technology to bear fruit and benefit all stakeholders in the procurement process, a clear and adapted legal framework is required.

Many jurisdictions have already adapted their guiding texts to take into account the development and dissemination of some of these technologies. A recent example is the

measures governing the use of civilian UAVs. In the United States, UAVs are managed by the Federal Aviation Administration, which regularly announces "changes to come" in the country's legal framework.[5]

Moreover, in considering technologies that are based on data transmission and analysis, legislation must particularly ensure that their use does not infringe on any of the following principles:

- **Transparency of public tenders and equal treatment of candidates:** A company should not be kept out of a public procurement process due to the excessive complexity or technical nature of the application procedures.
- **Business secrecy:** Automated data collection through blockchain or XaaS-based tools should not lead to the disclosure of confidential documents, including bids during a call for tenders.
- **Protection of intellectual property:** Plans and patents must not be used improperly, for example, when employing 3D printing.
- **Respect for personal privacy:** The right to anonymity and to the restitution and deletion of personal data should be guaranteed.

8. RELATION BETWEEN DTS AND A "RAMP-UP" ANALYSIS

1. **Levels of interaction between selected DTs**

As mentioned previously, some technologies require pre-existing tools before their benefits can be fully accessed. Therefore, using these preexisting tools in combination with new technologies should always be considered. The best example might be the joint adoption of RPA and AI, insofar as the latter allows the former to learn how to carry out its tasks on its own (research or data entry, in particular).

Depending on the project, DTs may even be dependent on each other. For example, the IoT can feed data analytic models designed to upscale the monitoring of contract executions. However, 3D printing has a special status in this respect, since this technology is completely independent of others (its use does not even require an internet connection).

2. **Theoretical order of DT implementation**

When placing each technology and its potential value addition in relation to the technological maturity that is required for its adoption, a theoretical "order of technology implementation" can be established for each group of countries (see chapter V).

It should be noted that in every group of countries, cloud and XaaS tools clearly appear to be the first DT to be implemented, which means that it is the one that requires the fewest number of technological prerequisites and at the same time the one that produces the most value added.

Another lesson that can be drawn from this analysis is that blockchain and AI technologies require the highest level of technological maturity before they can be implemented and used. As such, these technologies may require a longer time horizon before they can be implemented. This is particularly true for countries where the technological maturity of public procurement organizations is still quite low.

[5] FAA, "Recreational Flyers and Community-Based Organizations," https://www.faa.gov/uas/recreational_fliers/.

II. INTRODUCTION AND CONTEXT

IMPORTANCE AND SPECIFICITIES OF PUBLIC PROCUREMENT

According to the World Bank, "Governments around the world spend an estimated US$9.5 trillion in public contracts every year, which in many developing countries represents approximately **15–22 percent of GDP.**"[6] In Europe, it amounts to 14 percent of GDP.

Public procurement is expected to have a high impact due to its share of a country's national GDP. Its efficiency is proven by the quality of works, services, and goods delivered to the benefit of the community. Moreover, money spent by means of public procurement is injected mainly into the domestic economy. For all of these reasons, public procurement is a critical lever in supporting local economic development.

Public purchasers are key players in both public policy and the macro-economy, since they are the ones who create markets for a number of products or services that individuals do not buy themselves. In many sectors of everyday life, "such as energy, transport, waste management, social protection and the provision of health or education services, public authorities are the principal buyers." Beyond materially supporting public service delivery to the population, public procurement can serve as a policy instrument in and of itself, as it stimulates new activities and job creation in the private sector in order to fulfill public entities' needs.

Although public procurement offers a wealth of business opportunities, it is also strictly scrutinized in order to give the general public the assurance that public funds are handled in compliance with regulations, such as transparency and integrity, fair treatment of bidders, VFM, and fit for purpose.

OVERVIEW OF THE SOURCE-TO-CONTRACT AND PROCURE-TO-PAY PROCESSES IN PUBLIC PROCUREMENT

SOURCE-TO-CONTRACT PROCESS

Public procurement is generally analyzed through the STC process, which consists of preparing the tender, consulting the market, and managing the contract.

During the first phase, procurement officers proceed with budgetary and public tender programs. This is usually performed using offline or online tools in order to schedule the start of procurement activity based on a requested delivery date and on the cycle time of the procurement procedure to be used.

[6] World Bank, "Procurement for Development," https://www.worldbank.org/en/topic/procurement-for-development.
[7] European Commission, "Public Procurement," https://ec.europa.eu/growth/single-market/public-procurement_en.

For instance, when commodities are covered by an international public procurement agreement, there is a period during which the call for tenders must be advertised before bids can be opened. Although procurement officers generally share some knowledge of the procedures involved and standard specifications documents, a collaboration with requesters (prescriber/end user) is required for the sake of consistency and relevance. Also, during this phase, potential vendors need to be identified (sourcing activity) in order to see if there is a possible match on the market between public needs and vendors' offers.

The second phase usually has the highest activity workload, as the procurement entity faces the supplier market. Collection of bids, analysis of offers, negotiations, evaluation reports, supplier nomination, and contract authoring are carried out in compliance with the regulatory framework related to public procurement. For reasons outlined earlier, public procurement activities are diligently scrutinized, and certain legal principles, such as transparency and equality of treatment among suppliers, add up to considerable procedural requirements for public buyers. Internal requesters are also involved during this stage, in order both to validate vendor qualifications when it comes to the specified works, goods, or services and to act as clients for procurement officers, requesting a productive and short cycle time for the tendering activity.

The third phase is contract management: how the contract is implemented and how its performance is monitored. Since, upon the nomination through public procurement, the official owner of the supplier's activity is not the buyer but the requester, the management of supplier quality is the requester's responsibility (the internal client). That said, procurement has a role in supporting the internal client to assess the supplier's compliance with the contract, monitoring, how public funds are being handled during the contract's life cycle.

PROCURE-TO-PAY PROCESS

PTP covers three main stages: purchase requisition, purchase order, and receipt/settlement. Essentially this is a downstream phase with a traditionally long paper trail, as it corresponds to the actual disbursement of public funds.

First is the purchase order. This document demonstrates the public entity's commitment of funds to a given work, service, or good: for suppliers, it is the evidence that they can start the activity they have submitted a tender for, and for the public entity, it is the transition between a purchase request that was validated internally and a payment that will be made upon receipt. A purchase order needs to be validated by several authorized approvers based on the spend, the organization's procedures, and the commodity in order to authenticate the commitment of public funds, that is, to ensure that the request is legitimate, budget funds have been committed, and so on. Traditionally, this would be tracked in signature files and mailed to suppliers via postal mail services. Today, modern procurement systems offer digital approval workflows and enable order sending and supplier acknowledgement via email or electronic data interchange (EDI).

The payment to the supplier requires a series of operations that can be automated and generate high productivity gains, as these tasks are mandatory but have a low value added. During the match process, a comparison of potential discrepancies is made between the amount ordered, the amount received, and the amount invoiced. In most cases that have a "clean" dataset, the supplier sends an invoice after the delivery of the works, goods, or services and the performance of the service has been recorded and accepted by the public entity. Therefore, there is no gap, and the supplier's invoice can be paid after the payment term has expired. This is the best-case scenario. In reality, there can be many roadblocks in the process: the absence of orders due to a blocked signature workflow, a change in the supplier's legal name or bank account information, errors in enterprise resource planning (ERP), loss of invoices, and so forth

However, control is critical. There is a general principle in public procurement that says that the person who decides/approves expenses cannot be the same as the one who validates

its payment (segregation of duties). Put more broadly, the PTP cycle is not 100 percent complete without ensuring that there are some controls on the process. In recent years, supervising procurement management in the private sector and in public entities have emerged in order to analyze spending, optimize budgeting, and audit the performance and legality of public spending.

THE STC-PTP CYCLE

The distinction between both analyses stems from the differences in business processes, stakeholders involved, and contribution to the value chain.

This report will focus more on the STC process but will include some PTP cases where the use of DTs has had a critical impact.

III. DESCRIPTION OF THE DISRUPTIVE TECHNOLOGY

DTs are innovations that are expected to significantly change the way that public organizations handle their purchasing operations in the near future, both worldwide and locally.

Nine such DTs have been identified:

- Cloud Computing and "Everything" as a Service
- Big Data and Analytics
- Artificial Intelligence
- Robotic Process Automation
- Blockchain Technology
- Remote Sensing and the Internet of Things
- Drones/Unmanned Aerial Systems (UAS)
- 3D Printing/Additive Manufacturing

Although some of these listed technologies might appear already to be quite widespread, they have nevertheless been included in this study along with those that are more recent or still quite unknown. This is because the impacts of some now "common" technologies are not always well known or even assessed, particularly in the public procurement sector. Moreover, even the more commonplace technologies have not spread in the same way or at the same speed in all countries and regions of the world. For example, although SaaS solutions may not be considered disruptive in North America or Western Europe, they are clearly unfamiliar in countries where procurement procedures are still entirely paper-based.

Similarly, the present list of technologies does not include every innovation that may have an impact on public procurement. Selection of the technologies is based on their maturity, actual capacity to create value within other business sectors, and estimated ability to bring value to the public procurement process.

1. CLOUD COMPUTING AND XAAS

Generic description

- **Cloud computing can be defined as the delivery of on-demand computing services, from applications to storage and processing power, over the internet and on a "pay-as-you-go" model.** Users access computing services by means of web browsers, a computing model that shifts the computing workload to a remote location. Instead of owning their separate computing infrastructure (which entails significant costs) or data centers, organizations can rent access to anything from applications to storage from a cloud service provider.
- The existing market of cloud computing and XaaS solutions can be defined as an oligopoly. Cloud computing can be broken down into three cloud computing models (XaaS): PaaS, SaaS, and IaaS. The models depend on the different maturity levels. For instance, SaaS solutions are more mature and easier to implement than IaaS programs. Users can benefit from regular updates and personalized customer support. The technology maturity is

Figure 1. Summary Sheet - Cloud and XaaS

very high, and cloud computing–based solutions have already been successfully deployed under many different conditions. Due to its maturity, this technology is already being combined with machine learning.

Application to procurement

- When it comes to procurement, the maturity is between medium and high. Indeed, a growing number of public and private procurement organizations are transitioning from large complex ERP-built technology in favor of simpler platforms (end-to-end procurement steps) that are user-ready and far more

efficient than the previous solutions.

- This technology does have some issues, however. Indeed, relying on the cloud computing/XaaS models creates a dependency on the cloud vendor as well as a potential sovereignty issue (i.e., concerns about who would have access to the data). It also raises data and application security issues, as there is no single security standard.

2. BIG DATA AND DATA ANALYTICS

Generic description

- **Data analytics is the science of examining structured data and drawing conclusions from that information.** Big data analytics is the process of collecting, organizing, and analyzing large sets of raw data in order to discover patterns and useful information. These two technologies help organizations better understand the information contained within the data for decision-making purposes.
- The term "big data" refers to a massive volume of both structured and unstructured data that is so large that it is difficult to process using traditional database and software techniques. Analysts working with big data typically want the knowledge that comes from analyzing the information, a knowledge usually provided by data analytics. Therefore, these two technologies are frequently combined. Moreover, both technologies often rely on the same programming languages: Python/Java. The main "underlying" technologies are called Hadoop (a tool used for large-scale processing data) and MongoDB (a database for big data processing). The primary technology subsets are the NoSQL database (mechanism for storage and retrieval of data), predictive and prescriptive analytics, search and knowledge discovery, data integration/ preparation tools, and stream analytics. On the business side, the big data analytics market can be defined as a monopolistic competitive industry.
- Both technologies have a medium to high maturity level. They are both used successfully in many fields such as e-Commerce (price optimization) and marketing (social media analysis).

Application to procurement

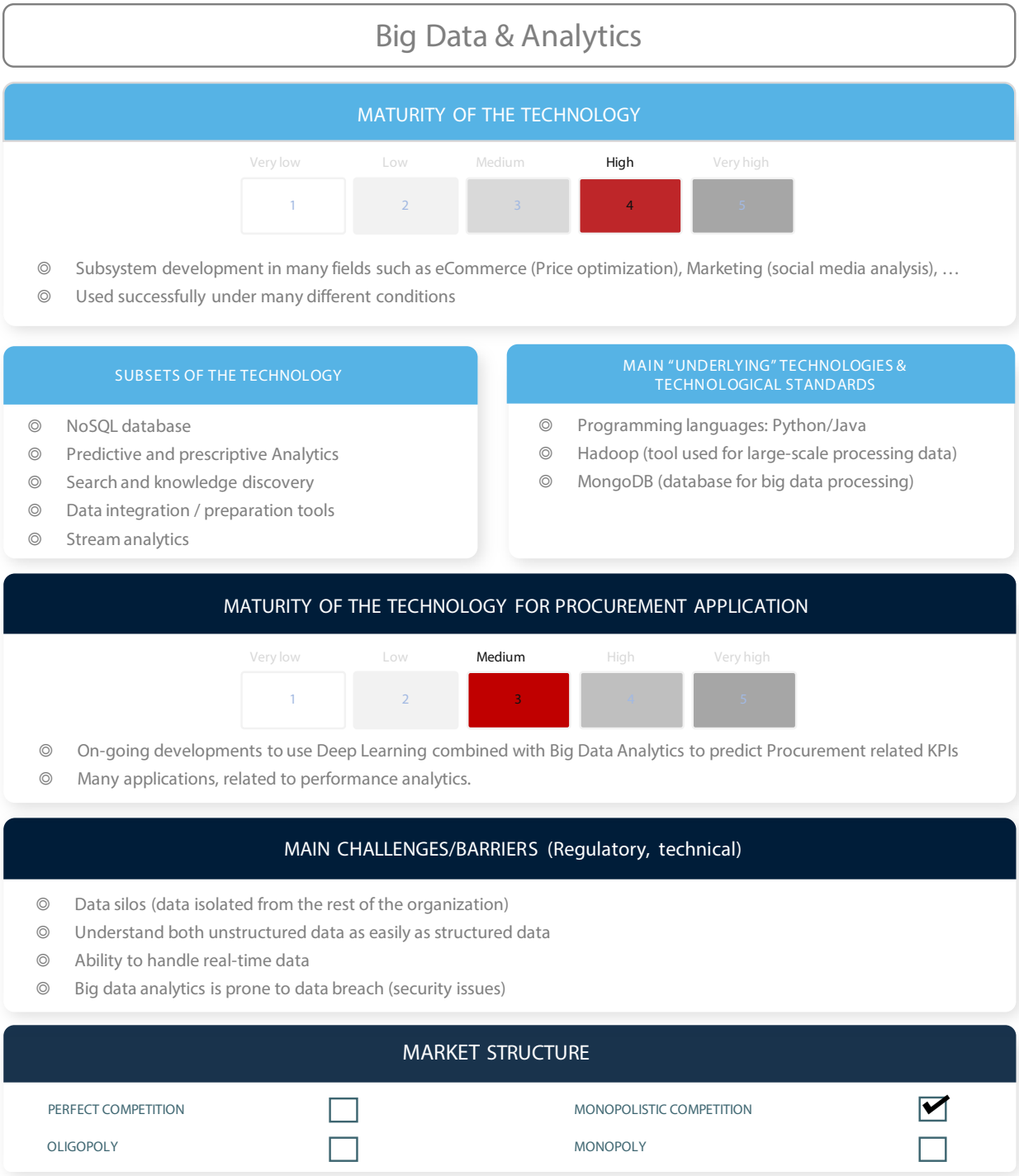
- **With regard to procurement, big data has between a low and medium maturity level, while data analytics is ranked as medium.** Many big data analytics applications are related to performance analytics.
- This level of maturity explains why it is not rare to find the use of deep learning (a subset of AI), combined with big data analytics, to predict procurement-related key performance indictors (KPIs). Leveraging big data analytics can help improve the internal position of the procurement function, from a department that is in charge only of cutting costs to key components of the overall business strategy. This technology combination has different roadblocks associated with it. First, data silos (data isolated from the rest of the organization) are common. Moreover, it can be more difficult to understand unstructured than structured data and to handle real-time data. Finally, big data analytics is also prone to data breaches (security issues).

3. ARTIFICIAL INTELLIGENCE

Generic description

- **AI is the ability of a computer program or a machine to think and learn. It is also a field of study (usually called computer science) that tries to make computers behave like humans. AI solutions work on their own without being encoded with commands.** In

Figure 2. Summary Sheet - Big Data and Analytics



other words, AI is a system's ability to correctly interpret external data, to learn from such data, and to leverage that learning to achieve specific goals and tasks. The explosion of available data and rise of computing power have fueled AI development worldwide. The most famous subsets of AI technology are:

- **NLP,** which can be defined as the ability to understand written text. It is used to create systems, such as speech recognition, document summarization, machine translation, question answering, autocomplete, and so on.

- **Computer vision**, which allows computers to understand and label images. It is used in driverless car testing, daily medical diagnostics, and other tasks.

- Despite being a monopolistic competitive industry, most AI projects rely on open frameworks and libraries such as TensorFlow (Google), CNTK (Microsoft), Torch, or Keras. The main programming language of AI projects is Python, and deployments are often made using Kubernetes, a system developed by Google for running and coordinating "containerized" AI applications. The overall maturity of AI as a technology could be ranked as medium. Indeed, users can already easily interact with AI in many fields, such as finance (fraud detection), recruitment (screening of job applicants), or medical diagnostics.

Application to procurement

- **Regarding procurement, AI's impact is ranked as between low and medium.** Several applications do exist, mainly to improve process efficiency (process mining), contract management, and spend analysis. Most projects are still only at the proof of concept (POC) stage.

- In the context of public procurement and AI implementation, several elements can represent roadblocks. First, it is key to mention that the use of public data within AI projects is often regulated, for example, by General Data Protection Regulation (GDPR) in the European Union (EU) and EU data privacy laws. Moreover, many countries lack relevant datasets (data that are used to train an algorithm to understand how to apply concepts). Finally, AI solutions require a trained workforce and the existence of a data culture—that is, the systematic gathering and storage of data.

4. ROBOTIC PROCESS AUTOMATION

Generic description

- **RPA refers to software that can be easily programmed to do basic and repetitive tasks across applications.** RPA creates and deploys a software robot with the ability to launch and operate other software. Designed primarily for office-type functions, RPA works like a digital assistant, doing routine and/or onerous tasks.

- RPA bots are simple and cheaper but are also technically more limited and often seen as a necessary step before the implementation of AI-driven solutions. From a technical perspective, the main programming languages are C# and Java. RPA solutions are often code-free for end users. Bots can be configured by nondevelopers using a graphical user interface.

- On the business side, the RPA market is a monopolistic competitive industry. There is a growing marketplace of commercial software vendors offering RPA. The market is also characterized by open source RPA tools and frameworks, such as TagUI, RPA for Python, Robocorp, and Robot Framework.

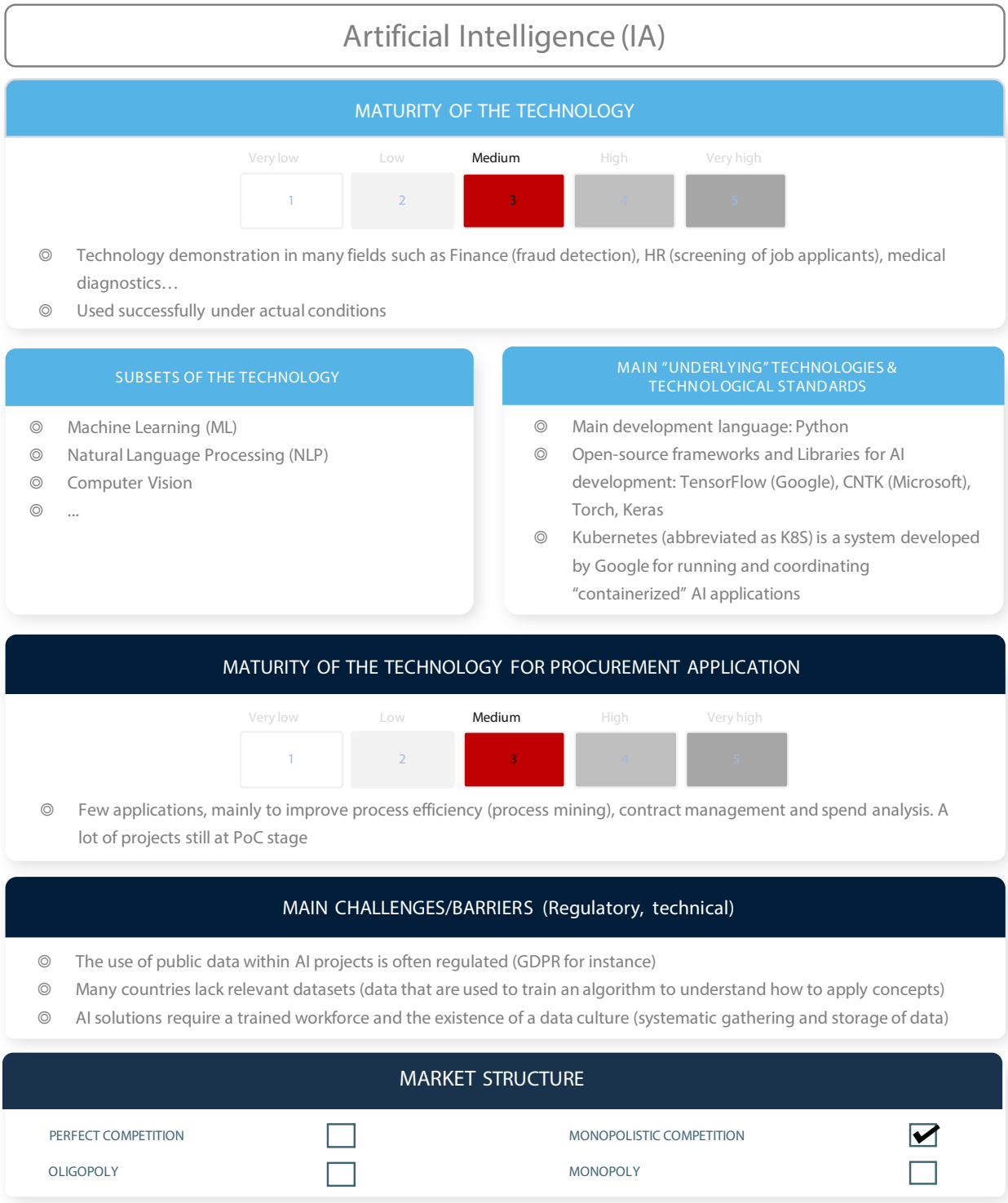
- As of today, the maturity of this technology can be defined as high. RPA-based solutions are already deployed in many fields, such as human relations (faster onboarding), marketing (competitive research), sales, finance, and others.

Application to procurement

- Regarding procurement applications, the maturity is medium. Several use cases of RPA in procurement have been identified, related mainly to the improvement of operational efficiency, compliance, demand and supply planning, and invoice processing.

- An RPA implementation is not without potential roadblocks. First, RPA bots cannot automatically adapt to process changes (RPA cannot learn from new data or detect

Figure 3. Summary Sheet - AI



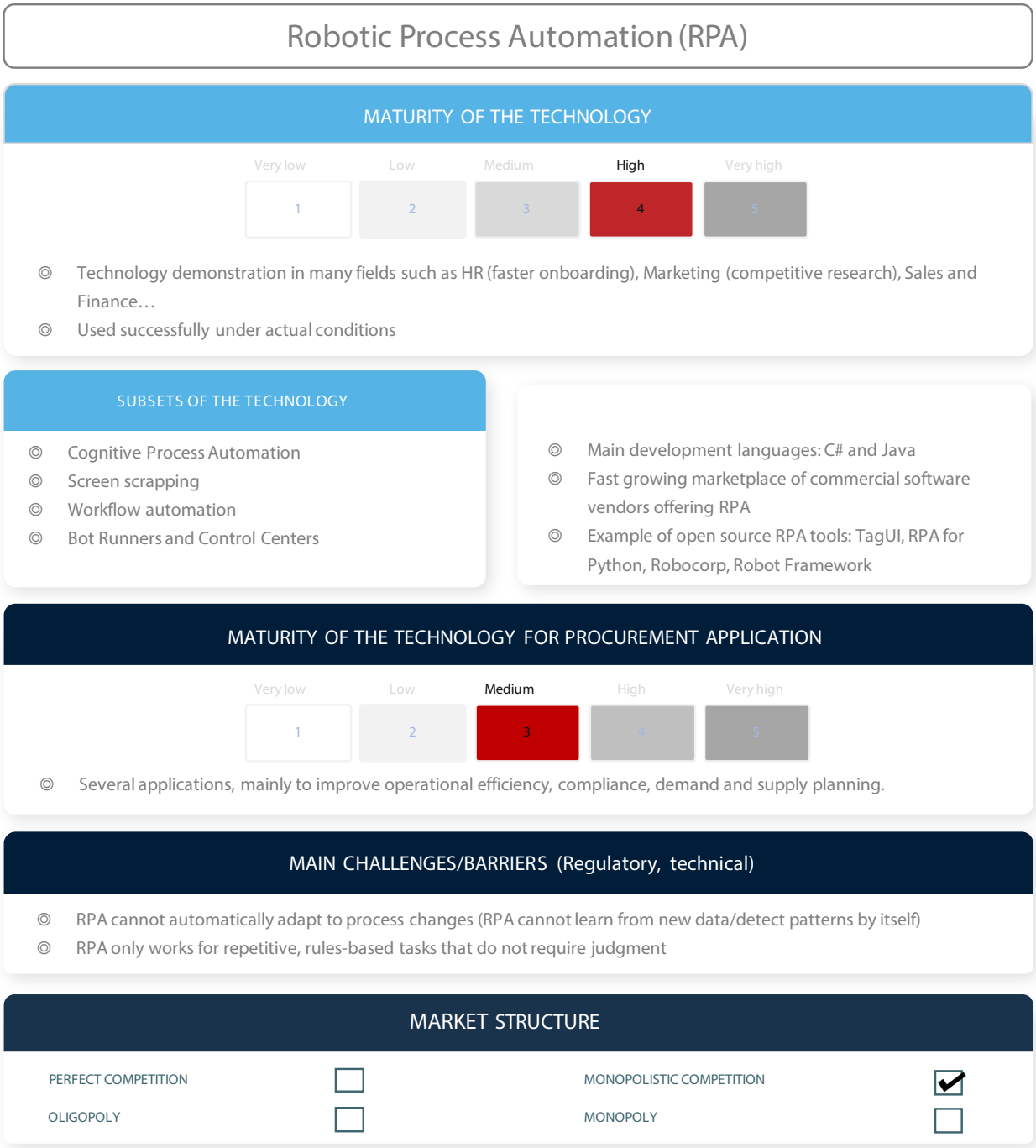
patterns by itself). Furthermore, RPA works only for tasks that are repetitive, that is, rules-based tasks that do not require complex logic.

5. BLOCKCHAIN

Generic description

- The key aspect of BCT is that it allows digital information to be distributed

Figure 4. Summary Sheet - RPA



but not copied. That means that each individual piece of data can have only one owner. Concretely, **BCT consists of a chain of consecutive "blocks" of transactions made in a decentralized network of computers (peer-to-peer networks). The blocks can be considered to be a container for the data. They cannot be altered without the agreement of the entire network.** Computers in the blockchain network are called nodes, and each node has a copy of the "digital ledger." Key BCT "subsets" are: distributed ledger technology (databases that are synchronized across multiple sites), peer-to-peer networks, consensus algorithms (used to gain agreement on a single data value), cryptography, and

hashing algorithms.

- BCT can help reduce risk, eliminate fraud, and provide transparency. Current projects seek to leverage blockchain as a medium for storing and validating business data without any "trusted third party." The overall technology maturity can be qualified as rather low. Although the benefits of BCT have been demonstrated in such fields as finance (cryptocurrencies, clearing, and settlement) and social media, only a limited number of organizations have succeeded in making a move from trials to fully production-ready blockchain.
- BCT has many barriers. First, processing times can be higher than in a centralized network as the number of computations on the client side increases. BCT also suffers from a lack of standardization and interoperability. The BCT technical landscape is fragmented, with multiple protocol specifications and frameworks being developed in isolation (Hyperledger, OpenChain, Corda, Graphene, Multichain, Exonum, and so on). Regarding the business side of BCT, it is a monopolistic competitive industry.

Application to procurement

- **When it comes to procurement, blockchain's maturity is low.** Few concrete applications exist, and these are related mainly to traceability. One famous use of blockchain in procurement concerns smart contracts, which are agreements among several participants in the form of computer code. These codes run on the blockchain, so they are stored on a public database and cannot be changed. The transactions that happen in a smart contract are processed by the blockchain, which means they can be sent automatically without a third party. A number of projects are still at the POC stage or have failed, mostly due to the scarcity of specialized development resources and to the complexity of the technical models, which require a lengthy implementation process. Ongoing developments primarily concern contract management and the security of the tendering process.

6. GEOTAGGING AND THE GEOGRAPHIC INFORMATION SYSTEM

Generic description

- **Geotagging is a technology that enables a user to automatically add data related to a location on different media, such as images, videos, text messages, or websites**. The global positioning system (GPS) and internet protocol (IP) address are used to generate a precise location. Geotagging is used by social media and for applications, such as, for example, Google maps, Flickr, and Picasa. A **GIS** is a computer-based technology that can capture, store, analyze, and manage geographic and spatial information. It is now used in all domains where location and historical analysis may be needed: fleet management, disease control, crop productivity, parking availability, live air traffic, and self-driving vehicles, to name a few.
- The subsets of these technologies are tools for the input and manipulation of geographic information, database management systems, and other software that support geographic inquiry and analysis.
- The technology's maturity is high and continues to evolve, thanks to other new technologies, such as big data and AI.

Application to procurement

- **Regarding procurement, the maturity can be qualified as low to medium, due to the few known use cases.** These technologies are used mainly to determine the sourcing strategy. GIS provides up-to-date information about supply/demand, market shifts, and

Figure 5. Summary Sheet - Blockchain

potential risks and can help sourcing professionals to formulate better category strategies. GIS may also facilitate contract management activities, for example, tracing the material flows, project location, and control of the number of trips/delivery frequency.

- The implementation of these two technologies can be limited by existing barriers. Indeed, despite being a rather accessible combination of technologies and the existence of open data initiatives that grant an easy access to data, having the necessary skilled personnel may be a challenge to their implementation.

Moreover, public acceptance also must be taken into account, since real-time geotagging provides the real-time location of the person operating the device.

7. THE INTERNET OF THINGS AND REMOTE SENSING

Generic description

- **The IoT is a technology that connects objects through the internet through a combination of hardware, communications technology, and data storage/analysis.** IoT helps in collecting a wide variety of elements from sensors, such as temperature, infrared, image, motion, presence of smoke, and so on. Ideally, sensors must be numerous to deliver sufficient data and lead to relevant analyses.
- The data collected from sensors are sent to a data storage facility for further analysis. Usually IoT and remote sensing data are combined with a big data analytics or data visualization tools or leveraged as a result of AI algorithms that find patterns in data. There are multiple solutions depending on needs and locations.
- **For short distance sensors**, Wi-Fi, Bluetooth, and Zigbee are often used. GSM and 4/5G are currently associated with long distances. Other alternative solutions involve LPWAN (low-power wide area network): Sigfox, or wireless networks to connect low-power objects, such as electricity meters and smartwatches, which need to be continuously on and emitting small amounts of data, and LoRa, a LPWAN protocol.
- **Remote sensing can be defined as the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft).** In remote sensing projects, special cameras are required to collect remotely sensed images. In agriculture, remote sensing can help procurement leaders better anticipate the need for specific items due to the evolution of large agricultural lands.
- **These technologies can be considered rather mature or medium according to the metrics.** There are currently numerous applications for IoT: consumer, medical, health, transportation, industrial, agriculture, and so forth.
- On the business side, the IoT market is a monopolistic competitive industry.

Application to procurement

- **In the procurement field, these two technologies have only a few concrete and proven use cases.** The main one is probably related to maintenance. Through this technology, it is possible to predict the life cycle of a machine and to anticipate the need to purchase new components or an entirely new device.
- It is safe to assume that in the near future, IoT and remote sensing, combined with other technologies, could help create new indicators related to demand estimation. These technologies do have barriers, however. First, the choice of IoT network can be cumbersome without expert help. Secondly, IoT raises major challenges related to security.

8. DRONES/UNMANNED AERIAL SYSTEMS

Generic description

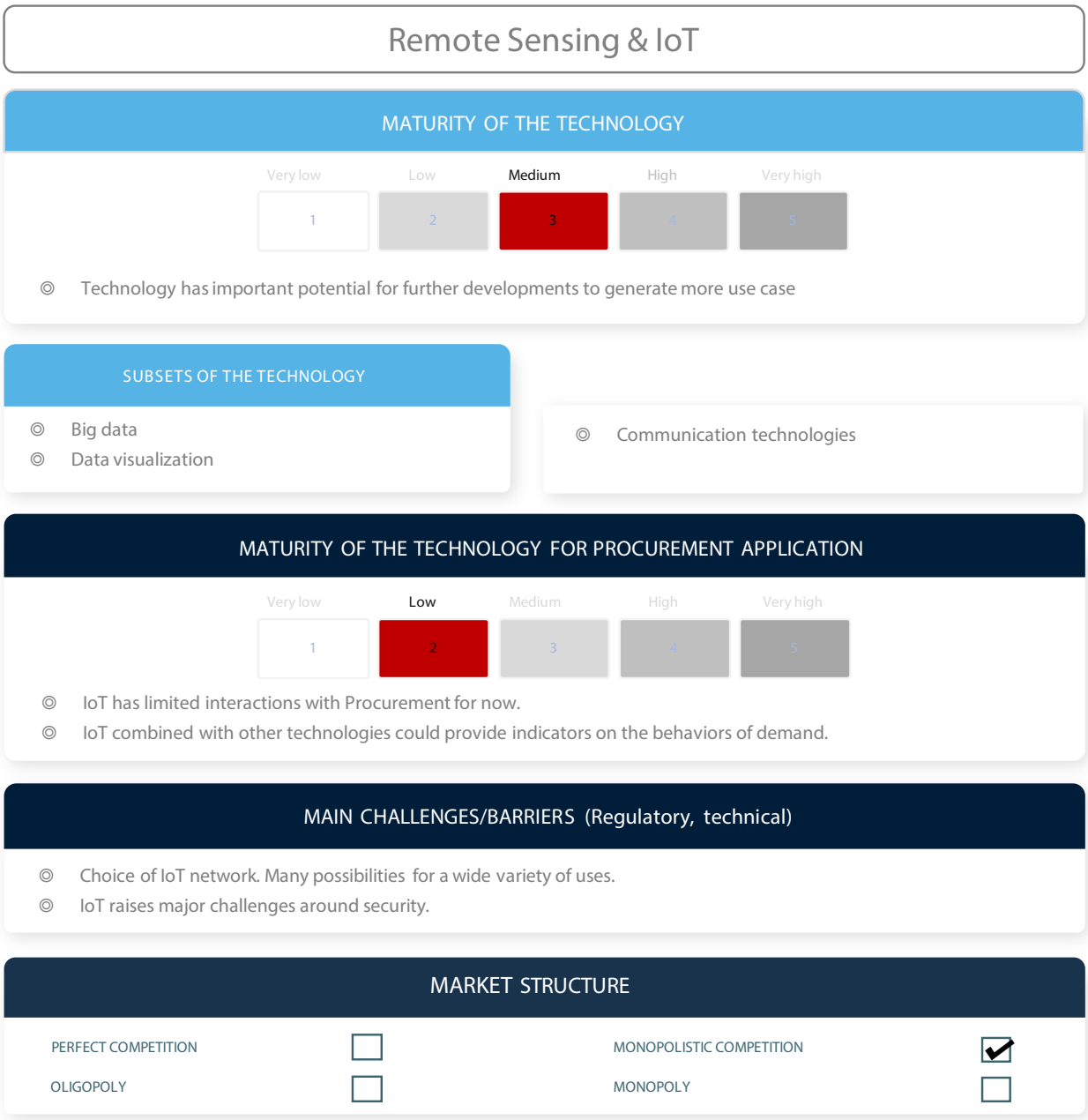
- **Unmanned drones (also UAS or UAV) can be guided autonomously by computers or remote control communications technology, and data storage/analysis.** As of today, they are mostly used by the military to perform dangerous missions, although civil applications have been developed to

Figure 6. Summary Sheet - GIS and Geotagging

cover several domains (recreational and professional).

- Today's professional applications vary from aerial photography or video surveillance and product delivery. The most mature applications involve short-range surveillance and associated photographs or videos. Drone inspections are also being used in almost every industry that requires visual inspections (often combined with AI) as part of maintenance missions (solar plants, railways, oil and gas infrastructures).
- The market for drone technology can be

Figure 7. Summary Sheet - IoT and Remote Sensing



qualified as **perfect competition**. Many companies already manufacture drones. The key subsets of this technology are autonomous flight, detect-and-avoid technology, air traffic management (ATM), and GPS.

- In general, the technology can be considered to be **mature enough** to demonstrate efficiency in many different fields. It has promising applications due to recent improvements in battery technology. For instance, start-ups in the United States have attracted more than US$3 billion in funding to explore new UAS applications, industries, and geographies.

Application to procurement

- **• The technology still has a relatively low maturity in procurement applications.** Indeed, only a few use cases in procurement exist. Its main impact is related to the way commodities

can be delivered: drones are starting to be used for deliveries on a small scale. UAS delivery services are expected to become widely available in the next five–ten years. Furthermore, some public authorities have already started using drones for the delivery of medical supplies in remote or less densely populated areas. **Thus, this technology may have a great impact on sourcing strategies within procurement organizations. It may also be used during the contract execution phase to confirm that certain contract objectives have been achieved and are in compliance with stipulated policies.**

- Drones present several barriers to consider before implementation. Regulations around the globe are not consistent, and some may slow down adoption. Moreover, as UAS complexity increases, so will infrastructure requirements for charging stations, landing facilities, and other assets.

9. 3D PRINTING

Generic description

- **3D printing (also called AM for additive manufacturing) is a technology based on the manufacturing of objects from a digital 3D model. Originally, 3D printing was used to create prototypes.** The goal was to save time and money by not creating molds and tools for low volume. The success and philosophy behind 3D printing, as well as regular innovations, have helped to rapidly expand the technology. 3D printing makes it possible for anyone with the right equipment to manufacture single parts or a small series of a given item (such as spare parts). 3D printing is very often local and on demand, so it improves the life cycle cost of the equipment and reduces parts inventories.
- 3D printing started with polymers, but metals, concrete, or ceramics can also be used as material through different manufacturing processes (see the section "subsets of the technology" in the diagram below). The introduction of new materials will help increase the technology's potential.
- The main underlying technology is the stereolithography (STL) file format (for 3D design software).
- **The technology maturity can be defined as medium.** Indeed, as noted above, the use of 3D printing has expanded rapidly in recent years, proving its ability to replace some traditional manufactured parts.
- The 3D printing market structure can be considered perfect competition. Various manufacturers of 3D printers exist, and there are numerous providers of prototyping services, using mainly SLS (a technique that uses a laser) or a technique that uses photochemical processes.

Application to procurement

- **In the procurement world, the maturity is between medium and high. 3D printing might offer many advantages to procurement departments,** including the fact that delivery time frames can be shortened and "spare tires" can be rapidly obtained, which could minimize business downtime and increase the longevity of infrastructure. 3D printing can be part of the sourcing strategy as the solution becomes viable and valued by engineers. Nevertheless, procurement departments have reported limited success in the adoption of 3D printing until only recently.
- The implementation of 3D printing is not without barriers. The major obstacles are often the right to use STL files (3D printed parts are protected by rights as original parts in commercial trade) and quality problems in the learning phase.

Figure 9. Summary Sheet - 3D Printing

3D-Printing

MATURITY OF THE TECHNOLOGY

Very low	Low	Medium	High	Very high
1	2	3	**4**	5

- Technology has expanded rapidly in the last years proving its ability to replace some traditional manufactured parts

SUBSETS OF THE TECHNOLOGY

- Stereolithography (source material is liquid plastic)
- Fused Deposition Modeling (heating a thermoplastic filament)
- Selective Laser Sintering (source material is powdered material)
- Laminated Object Manufacturing

MAIN "UNDERLYING" TECHNOLOGIES & TECHNOLOGICAL STANDARDS

- STL file format (for 3D design software)
- Various manufacturers of 3D printers
- Numerous providers of prototyping services mostly using Selective Laser Sintering or stereolithography

MATURITY OF THE TECHNOLOGY FOR PROCUREMENT APPLICATION

Very low	Low	Medium	High	Very high
1	2	**3**	4	5

- 3D printing can be part of the sourcing strategy as the solution becomes viable and valued by engineers.
- Procurement departments are reporting limited success in the adoption of 3D-printing

MAIN CHALLENGES/BARRIERS (Regulatory, technical)

- Reliability of items produced must be ensured and accountability of each party (owner of the file, manufacturer of the printer, procurement organization itself) must be clearly established in the case of potential deficiencies.
- In most cases, 3D-printed parts are protected by the same rights as original parts in commercial trade.

MARKET STRUCTURE

PERFECT COMPETITION	☑	MONOPOLISTIC COMPETITION	☐
OLIGOPOLY	☐	MONOPOLY	☐

IV. POTENTIAL USE OF DISRUPTIVE TECHNOLOGIES IN PUBLIC PROCUREMENT

In this chapter, the opportunities and risks presented by each technology at the different steps of the STC and PTP process will be detailed.

For each DT, a grid recalls the impacted steps. At the end of the analyses, balanced scorecards are proposed, allowing a quick evaluation of the opportunity that each technology represents for the optimization of the STC and PTP process.

The balanced scorecard includes the main benefits generated by the technology, the main associated risks, the prerequisites for the implementation of the DT, the use cases presented in the study, and the "related technologies and software," that is, those that, when implemented and used in conjunction with the DT under study, make it possible to increase or consolidate its added value.

The benefits are broken down into eight types:

- Business benefits
  - Quality direct value
  - Acquisition and operational cost
  - Delivery lead time
  - Productivity
- Compliance benefits
  - Transparency
  - Integrity
- Positive externalities
  - Economic development
  - Sustainable development

For each type of benefit, the value created by the technology is assessed (score out of five) on the basis of the experiences and literature studied. An overall benefit score is calculated by averaging the scores for each type of benefit, assuming equal weights for each.

The risks associated with the implementation of the technology are also assessed. They are of four types:

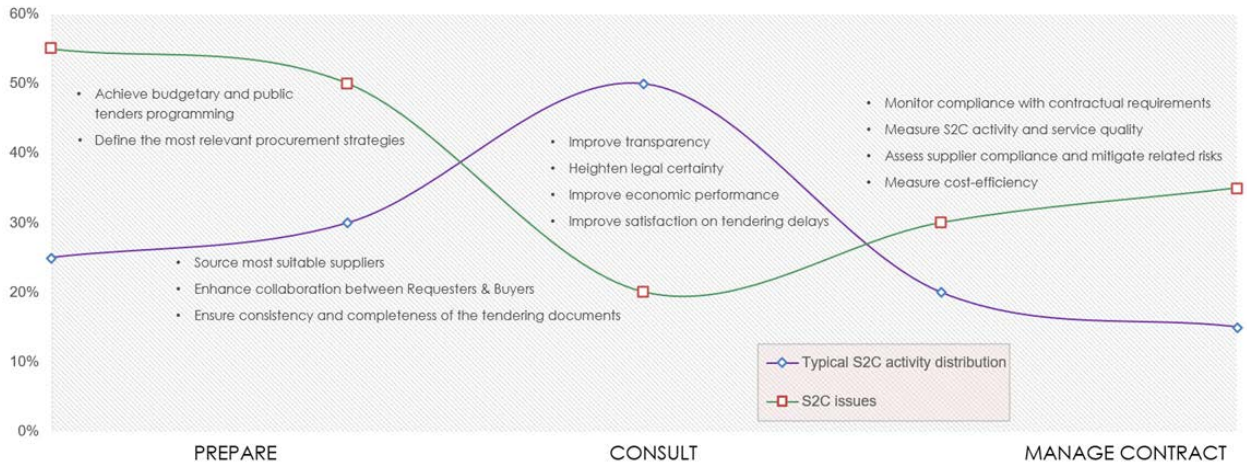
- Change management difficulty
- Negative externalities
- Regulatory barriers
- Technical maturity/durability issues

An overall risk score is calculated based on the ratings of these four types of risk. Additionally, the balanced scorecard gives a qualification of the costs induced by the first implementation of the DT and of the related payback time, which are assessed on the basis of observed use cases.

VALUE FOR MONEY OF EACH DISRUPTIVE TECHNOLOGY IN PUBLIC PROCUREMENT

The STC process **covers all core procurement activities**, from opportunity assessment through strategy planning, sourcing and negotiations, and contract origination. The nature of the STC process makes the technologies under consideration particularly promising. Indeed, it involves numerous analytical tasks and strategic decision making for which data compilation and retrieval or AI tools can provide valuable assistance. Moreover, new hardware solutions, such as drones or 3D printers, may considerably affect the procurement and sourcing strategies for certain types of goods.

Figure 10. Business Challenges - STC



The above graph presents the main business challenges along the three main phases of the STC process: **preparation, consultation, and contract management**. The **purple curve** stands for the evolution of the workload generated during the process, while the **green curve** represents the criticality level of its different stages. The conclusions to be drawn from this analysis are as follows: **the upstream and downstream phases of the process (preparation and contract management) are where the largest gains are made. It is therefore, appropriate to strengthen or equip these upstream and downstream phases and to lighten or automate the intermediate tasks as much as possible.**

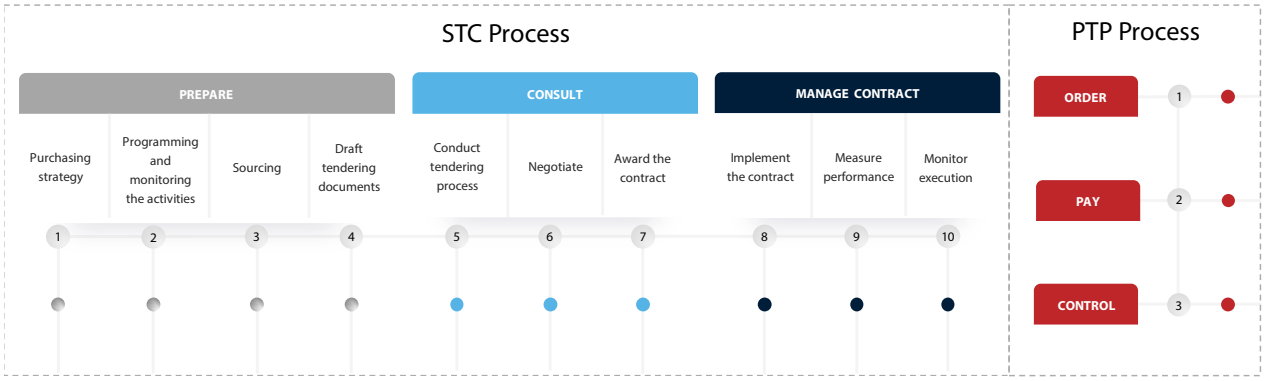
CLOUD AND XAAS

Since the SaaS delivery model for software was introduced in the procurement process almost 20 years ago, the solutions are mature and cover the whole STC process.

The STC suite are clearly mainstays for many private and public organizations and will remain relevant for the foreseeable future. They enable organizations to obtain the needed supplier results through a combination of different modules such as e-Sourcing to manage requests for information (RFIs) and RFQs, e-Auctions, contract lifecycle management (CLM), spend analysis, and supplier risk management.

Figure 11: STC-Impacted Steps - Cloud and XaaS

Steps of the procurement potentially impacted through cloud-based technologies



Although their use has remained rare in public organizations until recently, PaaS and IaaS technologies offer great opportunities in terms of data sharing, flexibility, and cost efficiency for public buyers. They both eliminate hardware installation costs and cut maintenance expenses, as these are distributed among clients in a dynamic and flexible way. Furthermore, these technologies enable different government procurement organizations to share data, which leads to standardized, optimized, and safer procurement processes.

1. **Direct benefits**

These solutions are proven in their ability to tackle such issues as low supplier performance, poor supplier selection process, the lack of clear spend visibility, and the absence of contractual agreement management. Benefits offered by an STC integrated suite are numerous:

More accurate decision making through more reliable data

- Cloud procurement solutions provide clear spend visibility. For instance, using a "spend analysis module," a public buyer can determine spending to date against a contract, whether all spending is at contracted rates, the total volume of a category, and whether spend on the category is increasing or decreasing.
- A "full suite" solution also brings visibility to the entire relationship with suppliers, from initial contract creation to final order delivery: the number of tenders the supplier participated in, the number of contracts, actual revenues generated by the supplier with the organization, and supplier performance based on internal audit campaigns. STC suites also provide easy access to the repository of the RFQs and more generally to bids/supplier data information.

Increased compliance and reduction of maverick buying

- Maverick spending can take many forms, including purchases made outside a preferred channel or supplier, or those that do not follow contract terms and miss out on negotiated savings. With an integrated solution, the system can easily monitor to see whether a requisitioned item, or equivalent substitute, is covered by a contract and if so, if the order is going to the contracted supplier.

Increased direct savings and higher value purchasing strategies for the buyer

- Shared procurement software may help buyers to increase their bargaining power in relation to suppliers and to evaluate bids and quotations more quickly. For example, powerful STC tools already provide buyers with access to previously signed contracts within a particular purchasing category and method. Additionally, almost all STC software now contains RFQ modules that enable the complete automatization of the analysis of simple quotations. These modules will soon be able to record settings and generate analysis models that should be suited to complex singular bids and also, to facilitate a total cost of ownership (TCO) analysis.
- Thanks to PaaS technologies, some additional levers may be actuated that should lead to optimized purchasing prices. For example, a predictive price and demand analysis or supply chain disruption forecasting models may be developed for some strategic products. PaaS technologies could thus help organizations determine the most appropriate time to renegotiate the conditions of critical contracts.

Improved internal collaboration between client, buyer, and supplier and reduced cycle times

- STC software speeds up the decision-making process and reduces the overall turnaround time of the awarding cycle through quick data retrieval and the seamless flow of information. For instance, with an integrated system, contracts can be made available to all parties involved in the supply management process that need them. Integrated solutions also allow for a more flexible role-based administration

of users. Organizations can create their own profiles and share them with others, which ensures adjusted scope and the rights of each user at any time.

- One successful implementation of cloud-based tools in public procurement is KONEPS in South Korea in 2002 (see chapter VI, Case #2). The early creation of a unique portal for all procurement-related tasks helped to save significant time and money. Today, more than 70 percent of South Korean public procurement is managed through KONEPS.

A guided decision-making process to fix process gaps

- Public and private procurement organizations are often faced with the challenge of enforcing procedures and ensuring that stakeholders adhere to the same documents and methods. Implementing an STC suite substantially helps organizations to spot process gaps and fix them as they happen to enhance process efficiency. For instance, the use of up-to-date tendering templates or internal rules in the process of evaluating and awarding supplier bids can be enforced trough predefined workflows.

Automation of low value-added tasks so buyers can focus on critical activities

- Automation can facilitate supplier onboarding and the maintenance of supplier data. For instance, an STC software system can automatically detect when compliance certificates are out of date. If a supplier still has active contracts or was selected for recent purchases, the system can automatically notify that supplier that an updated compliance certificate is required. PaaS solutions can also interface with national databases so that relevant information, particularly about suppliers, can be consulted by buyers and possibly be used to generate automatic alerts.
- Tendering and/or contract documents can be automatically generated through templates, and most data can be instantly propagated from the tender through the PTP modules.

Dynamic management of the tendering schedules and workload related to the STC process

- SaaS solutions have developed modules that enable a dynamic management of the workload. Thanks to such modules, public buyers can manage their tender schedules in a dynamic and interactive way, allowing them to address potential delays in the dialogue with internal clients and with management. Moreover, these modules calculate the workload carried by each buyer or by each division in real time. This enables the rapid detection of future workload peaks and a consistent reallocation of purchasing procedures.

2. **Complementary benefits of cloud-based technologies (shipment, invoice processing, spend management, etc.)**

- **These technologies provide clear and automated approval workflows** as part of the solutions. In most public organizations, procurement workflow approval is still a paper-based process, which is costly, time consuming, and subject to error. Automation eliminates the need for a lot of paperwork. For instance, procurement solutions grant end users the permission to request certain articles, while only managers can approve the purchase requisitions and convert them into purchase orders. Purchase requisitions can then be automatically routed to the appropriate approvers. Complex rules, such as spending thresholds and multi-manager approval for larger purchases, can also be implemented.
- Accounts payable automation is another area where procurement software is extremely valuable. Purchase orders are matched to their corresponding invoices, which are also matched to the receipt of goods and services in a process ("three-way match"). This is done through OCR (optical character recognition)-based

automation. These OCR systems learn rapidly, so speed and accuracy get even better over the long term. Up to 95 percent of invoices can then instantly be matched to purchase orders and can even be paid automatically in accordance with internal policies. This reduces the amount of time accounting employees spend on purchase order and invoice processing and increases the speed of order processing, thus allowing for better and improved tracking and approval of exceptions, or "corner cases." It also reduces errors and ensures timely and correct payments. This process optimization generates immediate and long-term savings through both initial and continuous improvements in efficiency. The procurement staff can stop devoting time and resources to low-value tasks and shift their focus to high-value activity.

- Some procurement suites allow for **easy access to records and facilitated searches.** This makes it easier to retrieve data on a particular supplier or transactions instantly rather than manually searching through files and documents. Buyers can easily access online catalogs from suppliers; get quick access to critical dates, obligations, and key terms; and view current contracts, amendments, history, and correspondence.
- It is possible to **store e-Procurement catalogs inside procurement solutions.** "Hosted catalogs" are particularly suitable to managing lists of a few hundred products and also guarantee price stability. "Punch-Out" catalogs are available through an interface between the customer's e-Procurement solution and the supplier's website and are more suitable to managing nonstrategic purchases with generally very broad offers.
- Cloud-based solutions also **enhance spend visibility.** Spend analytics, embedded in SaaS e-Procurement tools, make it easier to discover where and when maverick buying (purchase of goods and services from suppliers beyond a company's preestablished procurement policy) occurs and to take immediate corrective action, thus safeguarding compliance and procurement control. This generates significant savings by ensuring that the suppliers selected, and the conditions negotiated in the contracts are actually applied on a day-to-day basis.

3. **Increased transparency and integrity of public procurement activities**

- Workflow automatization and sharing, which is facilitated by STC solutions, also implies a strict separation and scheduling of tasks within the procurement process. For example, the system particularly guarantees that bids remain sealed until the time dedicated to bid submission is out.
- Furthermore, transparency between buyers and suppliers is also ensured, since all exchanges are recorded on the public tender portal and accessible by any bidder in real time.
- Since procedures are shared and uniform across the organization, data can be compared and analyzed on a large scale. This enables easier and unbiased audits of procurement actions and the faster identification of success factors.

4. **Compliance benefits and positive externalities**

- With data centers running in the cloud through mutualized infrastructure, cloud computing is theoretically more energy efficient than classic solutions due to the decreased electricity consumption. A survey conducted by Microsoft in 2018[8] found that relying on cloud computing could increase a business's energy efficiency by between 22 and 93 percent.

[8] "The Microsoft Cloud Can Save Customers 93 Percent and More in Energy and Carbon Efficiency," Microsoft News Center, May 17, 2018, https://news.microsoft.com/2018/05/17/the-microsoft-cloud-can-save-customers-93-percent-and-more-in-energy-and-carbon-efficiency/.

- It should be noted, however, that this gain may only be theoretical due to the "Jevon Paradox." This concept demonstrates that as energy efficiency increases, resource consumption also increases due to the demand stimulated by lower costs.

- Insofar as the purchasing SaaS suites are configured with standard processes, these tools secure those processes and make it possible to combat fraud or other irregularities.
- By facilitating the sharing of information among the various players and entities, cloud computing tools naturally lead to a standardization of the process. This facilitates large-scale analyses and increases the transparency of public organizations' purchasing activities.
- Better control of tendering schedules, facilitated access through the internet, and improved overall performance of public procuring entities will increase citizen trust and public sector accountability. This could also increase the participation of local and international private bidders, including small and medium-sized enterprises (SMEs), thus enhancing price competitiveness.

5. **Risks: change management difficulties, regulatory barriers, and negative externalities**

- Implementation of SaaS STC software can be challenging. The process of harmonizing the various steps and defining common principles can be very time-consuming and costly if not properly framed. Integration with existing legacy systems (ERP, accounting, etc.) can also be costly and complex. This is to ensure that the solution is a fit and will work seamlessly with other applications before an entity commits to the purchase. Moreover, the transfer of historical data on contracts, article catalogs, and even suppliers can quickly become a major obstacle. Finally, end-user training can be challenging, particularly for administrative personnel who have been using paper-based procedures for years, are struggling to change their habits, and may have an aversion to digital tools. Strategies to mitigate these risks are detailed in numbers 1 and 6 under the section entitled, "Key success factors and main risks to be mitigated," in chapter V.
- Another risk is defined approval rules that are too cumbersome for users and difficult to maintain over time. The level of control should be tailored to the issues at stake.
- It is also key to avoid overly complex settings or specific developments during implementation that prevent upgrades and become very expensive to maintain. These deviations from software standards should be avoided, as they slow evolution capacities enormously and make any modification very complicated. In other words, the customer no longer benefits from the SaaS model. Thinking too big is also a fairly common mistake. In today's SaaS world, it is common to test drive the software, usually via a sandbox (a virtual space in which new or untested software or coding can be run securely) to ensure that the solution is appropriate and will work with other applications. Strategies to mitigate these risks are detailed in numbers 3 and 6 under the section on success factors and risks in chapter V.
- Regulations, such as the GDPR, will continue to affect cloud computing. A cloud service provider processes personal data stored within databases or servers on behalf of the client. According to the GDPR, personal data may not be kept longer than needed for the predefined business purpose. This means public/private organizations and their service providers must purge records whenever necessary. To ensure full compliance, backups must also be identified and deleted. The GDPR also ensures that data storage in the cloud is encrypted and that there is a disaster scenario procedure to respond to any breaches.
- In countries with relatively unstable internet connections or prolonged

electricity outages, the dematerialization of processes can potentially block or partially slow activities. A permanent internet connection is at the heart of cloud computing technologies. If this is not guaranteed, it is essential to keep backup solutions for data storage and more generally to pay attention to the dependence upon data stored on the cloud.

6. **Mitigation measures**

- Mitigation measures are outlined in chapter V, where a number of good practices are considered to address the following risks:
  - Reversibility and dependency issues
  - Procurement complexity and difficulty in specifying
  - Adoption concerns

7. **Prerequisites**

- Data availability and quality can be one of the biggest causes of delays during the later stage of the project life cycle. Having supplier and contract data updated and organized before the project starts can really speed up the implementation process.
- To minimize the unpredictable costs of implementation, it is important that user and transaction volumetric be specified, and that traffic is estimated in advance.
- The organization must ensure that it has the critical size to embark on such a project. For example, the return on investment (ROI) of a complete dematerialization of the ordering process requires a significant volume of invoices.
- In the SaaS world, it is common to test a solution before adopting it.

8. **Balanced Scorecard**

- See Figure 12.

BIG DATA AND ANALYTICS

Public procurement professionals are already surrounded by a tremendous amount of data, both visible and hidden. **Public organizations are just beginning to tap into this opportunity to rethink the way they work.** Out of the enormous quantity of recorded data, public buyers may draw valuable information from open data sources, such as online procurement notices, national databases, public reports, open statistical studies, or activity reports from publicly traded companies. By identifying the relevant sources of information and connecting to it, organizations may ensure safe and optimized STC processes.

As of today, big data and data analytics in STC is more a potentiality than a reality, even in countries with well-established public procurement information systems.

Figure 13. STC-Impacted Steps - Big Data and Analytics

Steps of the procurement potentially impacted through Big Data technologies

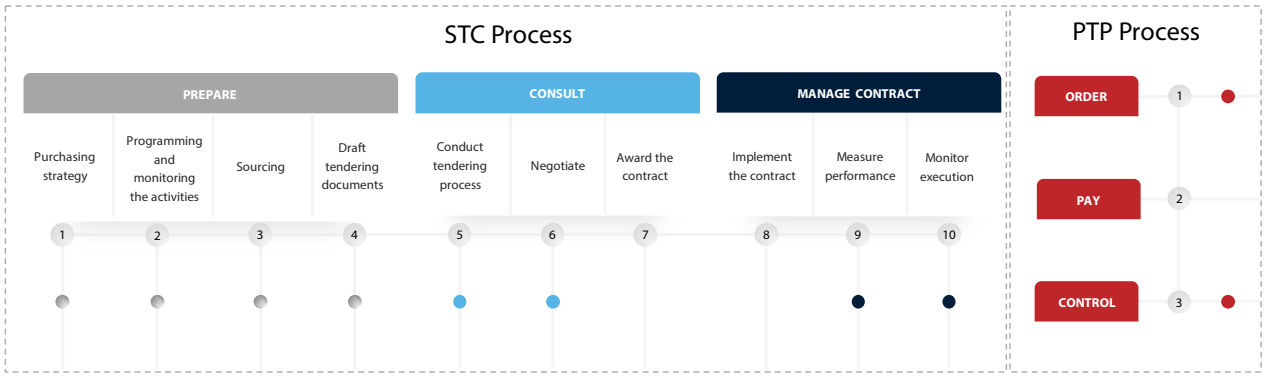
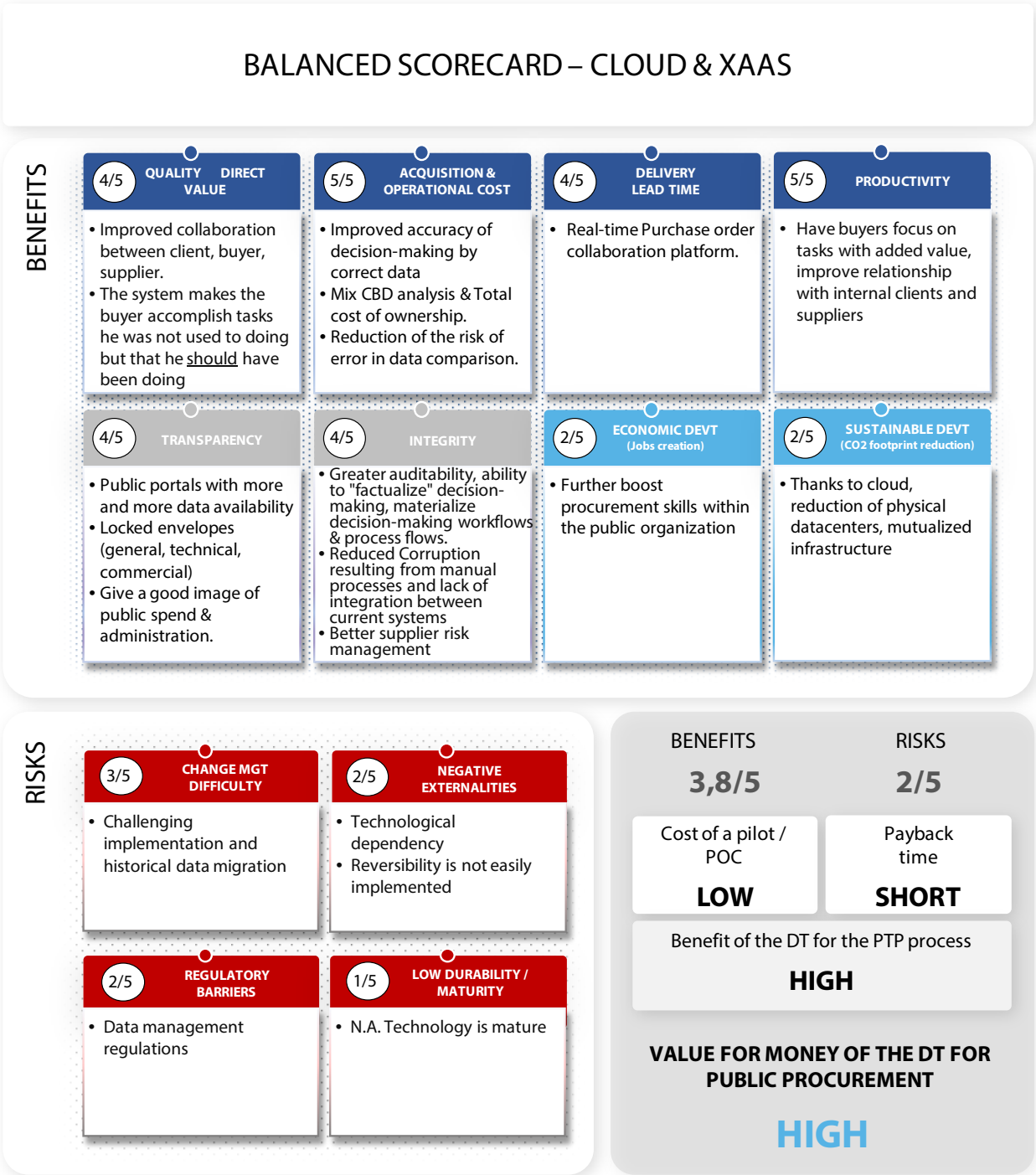


Figure 12: STC Balanced Scorecard - Cloud and XaaS



Use cases

- New eProcurement system for The City of New York (IVALUA)
- New eProcurement system for the State of Maryland (USA) to streamline the procurement process (IVALUA)
- Portal KONEPS in South Korea

Prerequisites

- STC sub-processes and internal procedures clarified
- Data available

Related technologies & software

- Internet of Things
- Blockchain
- Big Data & Analytics

1. **Direct benefits**

Leveraging big data and data analytics in public tendering procedures and supplier/spend management offer the following opportunities:

Enhanced spend management: Big data/ data analytics can substantially improve the classical spend analysis routines:

- **Offering the ability to "drill-down" to the finest level of granularity** (i.e., products, invoices). Buyers spend considerable time gathering detailed information once they have identified an opportunity. Most proficient data analytics work like a two-way street: they help identify trends and patterns and make it possible, at a minimum, to display, navigate, and zoom in and out.
- **Treating and representing spend data by work or consumption unit.** This is in order to identify usage and consumption patterns (spends per square foot, per internal customer, per initial equipment, and per employee). These consumption metrics can definitely help the buyers work with internal customers on how to minimize the cost drivers. They may also help buyers to see beyond the barriers that exist between departments and organizations and justify the undertaking of cross-functional actions.
- **Enriching existing reports with external sources.** For example, alerts about supply risks may be fueled with open or private data, such as raw material prices, country risk ratings, supplier certifications, or supplier inventory levels.

Facilitating sourcing, evaluation, and negotiation preparation

- Buyers spend considerable time gathering the information needed for their sourcing and negotiations. Big data, combined with open data, may drastically increase the efficiency of the public buyer, allowing for quick and complex analysis and inquiries previously not possible. Examples of applications include:

    1. **With increased capacity to identify best practices,** it can be possible to get the latest tender documents published nationwide on a given common procurement vocabulary (CPV) code in one place. This will enable a rapid benchmark on specifications, type of procedure, contracting system, type of processing, contracting body, place and deadline for submission of tenders, participation requirements, award criteria, subcontracting conditions, contract modifications, and so on.
    2. In some cases, big data might also identify **bundling opportunities** with other contracting authorities.
    3. **Time saving in sourcing activities** is possible through rapid access to the list of awarded suppliers on a given CPV code. Some government initiatives to aggregate the award fields from the procurement notices have already been implemented (aggregation of the winning company, award price, number of received offers for each tender).
    4. **Improved budget forecasting** can be available through the aggregation of the awarded amounts and the percentage of discount obtained compared to the forecasted budget.
    5. An **improved capacity to identify relations/correlations** and detect anomalies in supplier offers is also likely.

- In Brazil, datasets have been used since 2016 that provide public procurement organizations with comprehensive and constantly updated information about supplier prices. Indeed, it is mandatory by law in Brazil to conduct price research as a preparatory task before launching a public procurement procedure. The use of big data technologies by Brazilian procurement organizations has brought more efficiency to procurement strategies and more transparency to the process (see chapter VI, case #5).

Increased capacity to detect public corruption and better risk management

- Big data makes it possible to address the wide variety of risks encountered across public procurement activities and to find correlations between different datasets that might be meaningful. The applications are extremely valuable for public procurement:
  - Increased capacity to detect unreasonable offers and to access bid data in related markets with similar characteristics
  - Increased capacity to detect public corruption and suspicious patterns as each awarded contract is tracked:
    - Identification of the firms that are repeatedly awarded contracts
    - Links between different national databases, allowing for direct access to the beneficial ownership of contracting firms, direct access to public officials' tax and family records, and complaints to the authorities about bribery from competing contractors
  - Limited "adverse selection issues" and "moral hazards" thanks to an aggregation of contract failures and a supplier rating that depends on the supplier's involvement in litigation and on the number of contracts that have been prematurely broken or have incurred penalties in the past
  - Highlighting of shortage and supply-chain risks for sensitive products, which can be done by consolidating information, such as the suppliers' country risk, the number of approved subcontract manufacturers or transporters, or the evolution of global demand for the product

Supporting government accountability

- By increasing transparency, big data and open data are two key factors that can help government procurement become more efficient. This could benefit society as a whole through the acquisition of tools to detect fraud, the use of econometrics and statistics, and the ability to verify the implementation of public policies through public tenders.
- It can also help restore the confidence of citizens and local businesses in the public procurement system through the transparency of awarded suppliers on a national scale and the transparency of essential data, for example, the percentage of the market awarded to SMEs. Portals dedicated to public procurement have started to emerge, allowing the citizen to be better informed and in the near future to carry out controls ("watchdog portals").

2. **Complementary benefits of big data and analytics (shipment, invoice processing, spend management, etc.)**

- Open data and data analytics **can lead to more accurate "demand forecasts."** The analysis of open data should allow procurement organizations to estimate future needs and consumption patterns and to anticipate corresponding orders. Rather than ordering after operational departments have expressed a need, information systems can predict that need based on information related to historical data. Certain requirements can also be anticipated, based on information provided by open data sources (for instance, the amount of waste to be treated within a given area may depend upon the number of tourists, the weather, or the amount of consumer goods purchased by the local population). Once patterns are established and factors of demand identified, tools can automatically draw the required information from open data sources.
- Big data **can help evaluate and prevent supply chain risks.** The systems can search and harness open data covering the entire supply chain of a given item and thus provide comprehensive risk analyses. This open data might be the price of required raw materials, country risks of production sites, or potential

changes in the applicable legislation. These features are even more relevant and helpful for organizations that purchase sensitive products such as pharmaceuticals. The systems can provide a better overview of suppliers' production capacity, thus avoiding urgent orders being issued to suppliers whose production lines are already at full capacity.

- Analytics can directly improve procurement techniques. Data analytics can be used for in-depth analysis that allows a real steering of the quality of the procurement activity. It can be used to consider:
  - Opportunities for group orders in order to negotiate better prices
  - Opportunities to reduce transport costs thanks to consolidated deliveries
  - Purchase requests over recurring items that could be the subject of a contract, which would mean significant gains on key orders
  - The administrative behavior of suppliers and the opportunity to take corrective action: order confirmation time, compliance rate with administrative processes, and so on
  - Statistics on compliance with delivery times
  - End-to-end processing time statistics: from processing of the purchase request to receipt of the goods/ services
  - The percentage of urgent purchase requests by organization (planning issues to be resolved at the source with the respective organizations)
  - Potential problem of order delays: analytics can help identify sources of the delay, in particular when it is complex or multifactorial, and eventually incorporate those factors into the dialogue with internal customers, which may improve the image of the procurement departments within the organization
  - Spend control of current contracts (real-time analysis of important indicators, such as, for a given product, the quantity of corresponding consumable items used by a particular department)
  - An analysis of simultaneously different datasets to help identify trends and practices that do not appear when they are considered separately (e.g., fraud, abuse)
- Big data can be used to better manage supplier offers. Using big data technologies can lead to the creation of comprehensive supplier catalogs. Indeed, such information as price, availability, and other selling conditions can be gathered from several catalogs or from open data sources. Buyers do not have to consult numerous catalogs for each purchase request, and supplier and product data are updated automatically.

3. **Compliance benefits and positive externalities**

- In addition to the aforementioned contributions of big data to increasing transparency and restoring the bond of trust between citizens and public organizations, these technologies present real opportunities to support sustainable economic development approaches.
- Aggregating data on supplier performance or on contracts that have led to disputes or holdbacks would certainly result in a virtuous circle and have a reputational effect by encouraging suppliers to meet their commitments and providing real value to public purchasers.
- With big data, it is now possible to set up national comparisons on sustainable development indicators associated with public procurement. For example, in Europe, initiatives are underway to classify awarding authorities according to the share of purchases made from SMEs or from eco-responsible labels.
- Optimizing deliveries and grouping numerous orders together, made possible

by big data business intelligence, can contribute to the reduction of CO2 emissions.

- Big data technologies foster employment and economic development since they require qualified people to work with data on a full-time basis, such as data scientists, data analysts, and so on.

4. **Risks: change management difficulties, regulatory barriers, and negative externalities**

- Developing or implementing these technologies requires a data-driven mindset within the organization. Since data have to be reliable and structured to be analyzed and bring value, all stakeholders must be aware of data quality, or an organization might draw the wrong conclusion.
- Linking different procurement data systems, standardizing data formats, and establishing a robust procurement data management infrastructure are not easy tasks.
- The quality of raw data is a problem: it may be empty or contain conflicting data or errors. The content of many of the open data fields is text-based, which makes it difficult to use them in calculation models.
- Data systems for public procurement also require extensive collaboration among several disciplines, such as political science, economics law, or information technology. The successful use of large amounts of data requires reliable and readable indicators to give meaning to the enormous diversity they reveal.
- Greater transparency can enhance government accountability by empowering society to scrutinize civil servants, which could also derail innovation and force civil servants to choose less risky strategies rather than seek VFM.
- Active change management is important. Stakeholders that might worry about data collection have to be reassured, which is possible only if data collection and the dissemination and use of the information do not contravene applicable regulations.

5. **Mitigation measures**

- Mitigation measures are outlined in chapter V, where a number of good practices are presented to address the following risks:
  - Procurement complexity and difficulty in specifying
  - Adoption issues

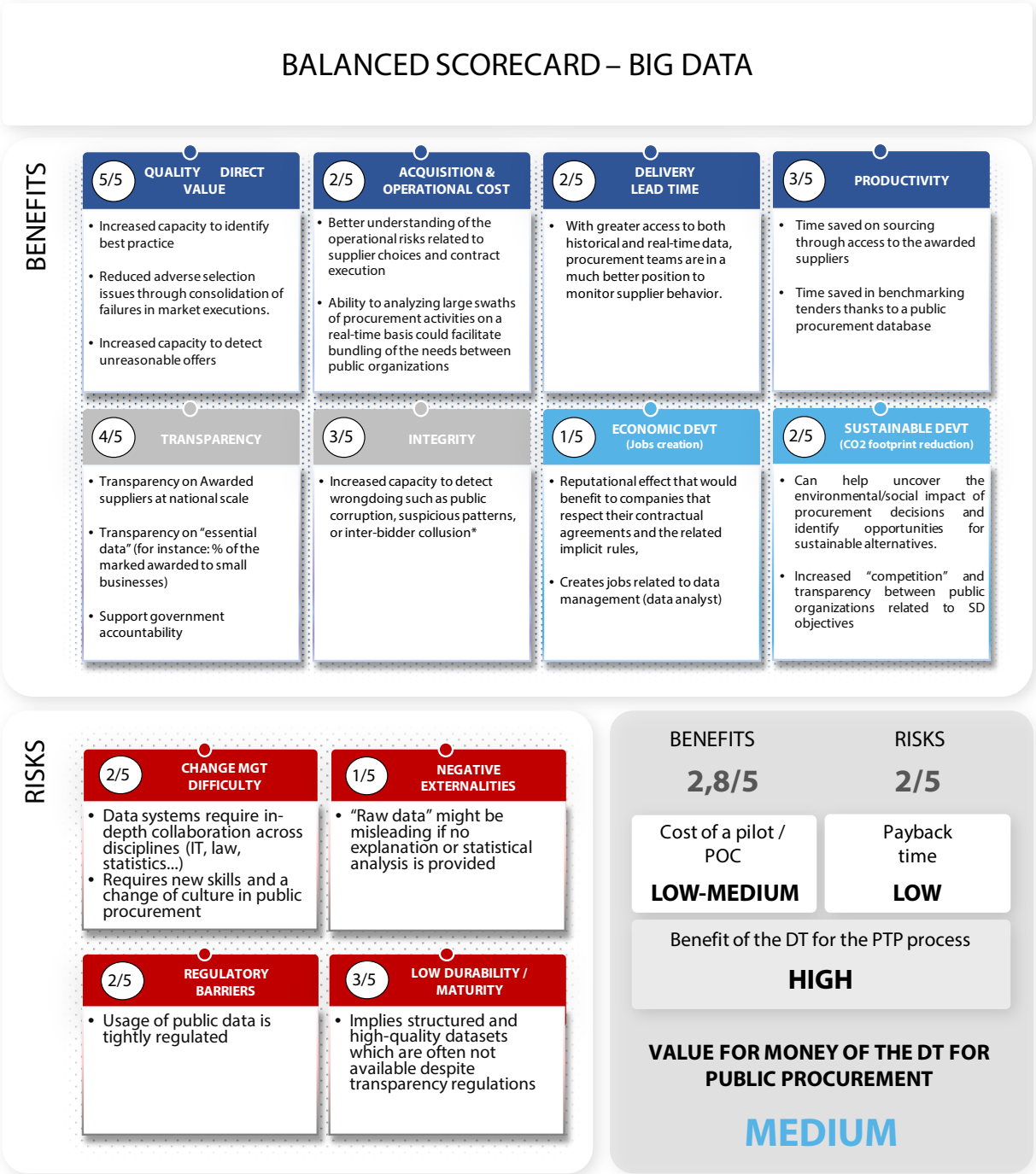
6. **Prerequisites**

- The collection of unit prices is critical to identifying potential savings. Although this is done in Brazil, where the World Bank conducted data analytics and provided different scenarios of cost savings, it is not possible in countries that use e-Procurement systems without fulfilling the requirement of collecting unit prices.
- More generally, even the most comprehensive data system for public procurement is of limited use if it is not structured: information has to be collected and stored in a suitable database format. On the other hand, the data structure must be understandable to stakeholders and stable over time so that past data may be used to anticipate future transactions. Existing standards are already designed to help organizations fulfill these two objectives. For example, the Open Contracting Data Standards (OCDS), which have been adopted by numerous public and private organizations, are designed precisely to generate and use open and reusable data that are to be read by both humans and machines.

7. **Balanced Scorecard**

- See Figure 14.

Figure 14. STC Balanced Scorecard - Big Data



Use cases

- Federal Ministry of Economy, (Brazil) – Better Market price Research

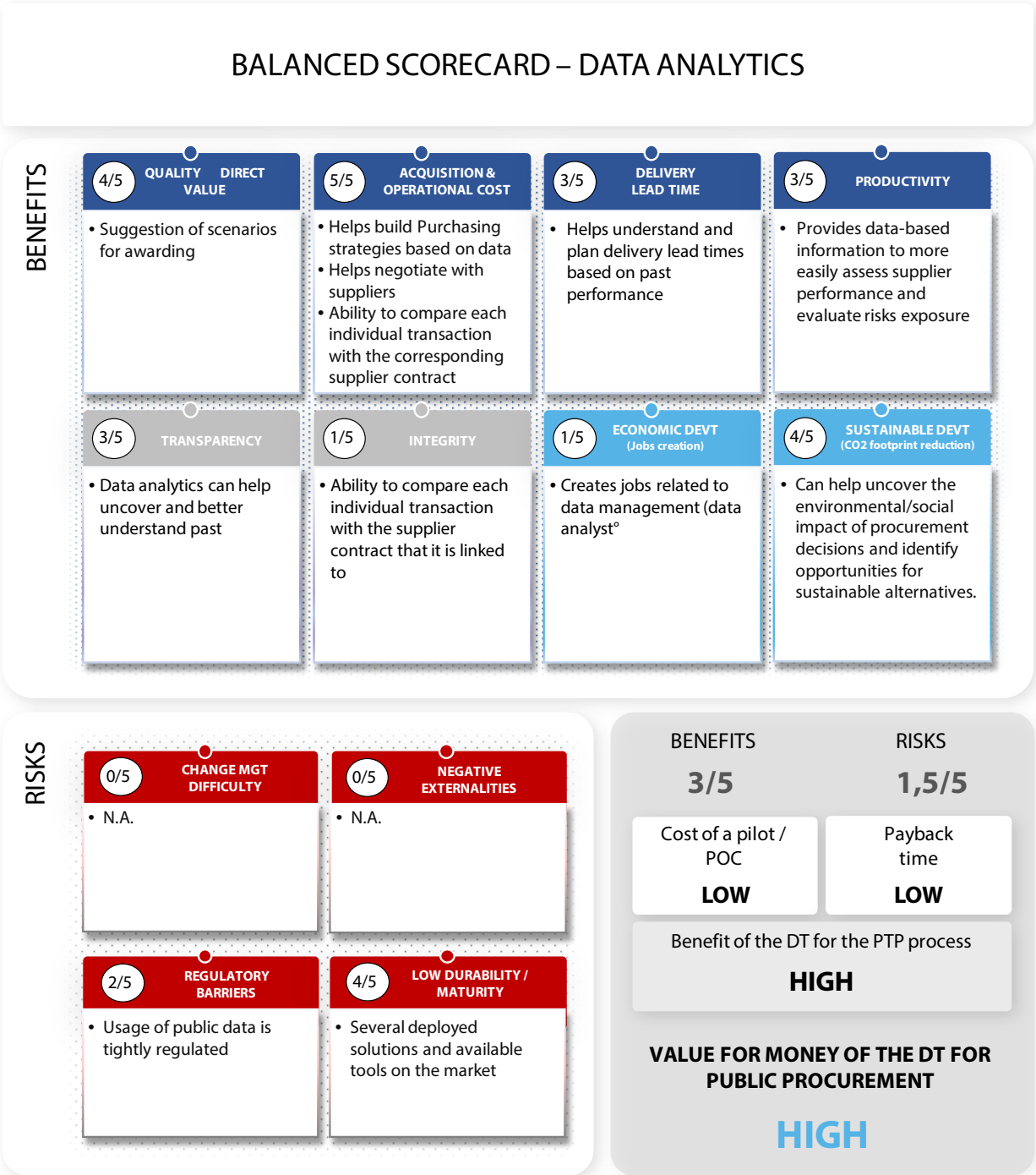
Prerequisites

- Vast amount of data required
- Open, machine readable, and accessible data

Related technologies & software

- Data Analytics
- Open data

Figure 15: STC Balanced Scorecard - Data Analytics



Use cases

- State of New York, (USA) – Strategic sourcing using data analytics for discounts

Prerequisites

- Access to structured data
- Procurement analytics tool

Related technologies & software

- AI
- Big Data

RPA AND AI

The application potential of these two technologies covers all the stages of the STC process. **Some solutions have already been deployed and some are still in the POC stage.**

1. **Direct benefits**

Automation of low value-added tasks in the public tendering and contract execution process

- RPA bots can be programmed to manipulate existing procurement software in the same way that a person does. Several tasks can be immediately impacted:
  - RPA tools are currently being used to automate supplier onboarding procedures that tend to be lengthy and prone to manual errors. This includes background checks, supplier document review, and pursuit of suppliers when information is missing. In the United States, the Federal Acquisition Service created a bot (named Truman) in 2018 to validate whether a vendor was eligible to do business with the government. Thanks to this application, the contracting specialists can now spend more time on value-added activities (see chapter VI, case #6).
  - Bots have the capacity to crawl the organization network and scan paper documents in order to populate data in the procurement system. Bots can also identify missing documents/application forms in the offer submitted by a vendor and automatically proceed to a call for an amendment.
  - Other bots and AI applications are still POCs, such as the automated generation of a (draft) version of the analysis report through NLP.

Automation of all activities related to master data management (MDM) data extraction and "dirty" interfaces through RPA

- Procurement organizations often face difficulty in maintaining data sources from which systems can get relevant information. For example, vendor MDM involves compiling supplier names, physical addresses, telephone numbers, e-mail addresses, and so forth so that a "single source of truth" provides all the elements referenced by other systems. Procurement bots can help eliminate risks associated with those unstructured and repetitive tasks and rules. They are ideal tools for automating parts or all of these processes, which leads to a more efficient overall governance of the MDM.
- RPA solutions can also be used to manage "dirty" interfaces in which data, printed or handwritten, need to be transferred between applications that are not integrated (e.g., automatically updating contract values with payment dates from a document in the company's contract management system to the revenue management system).

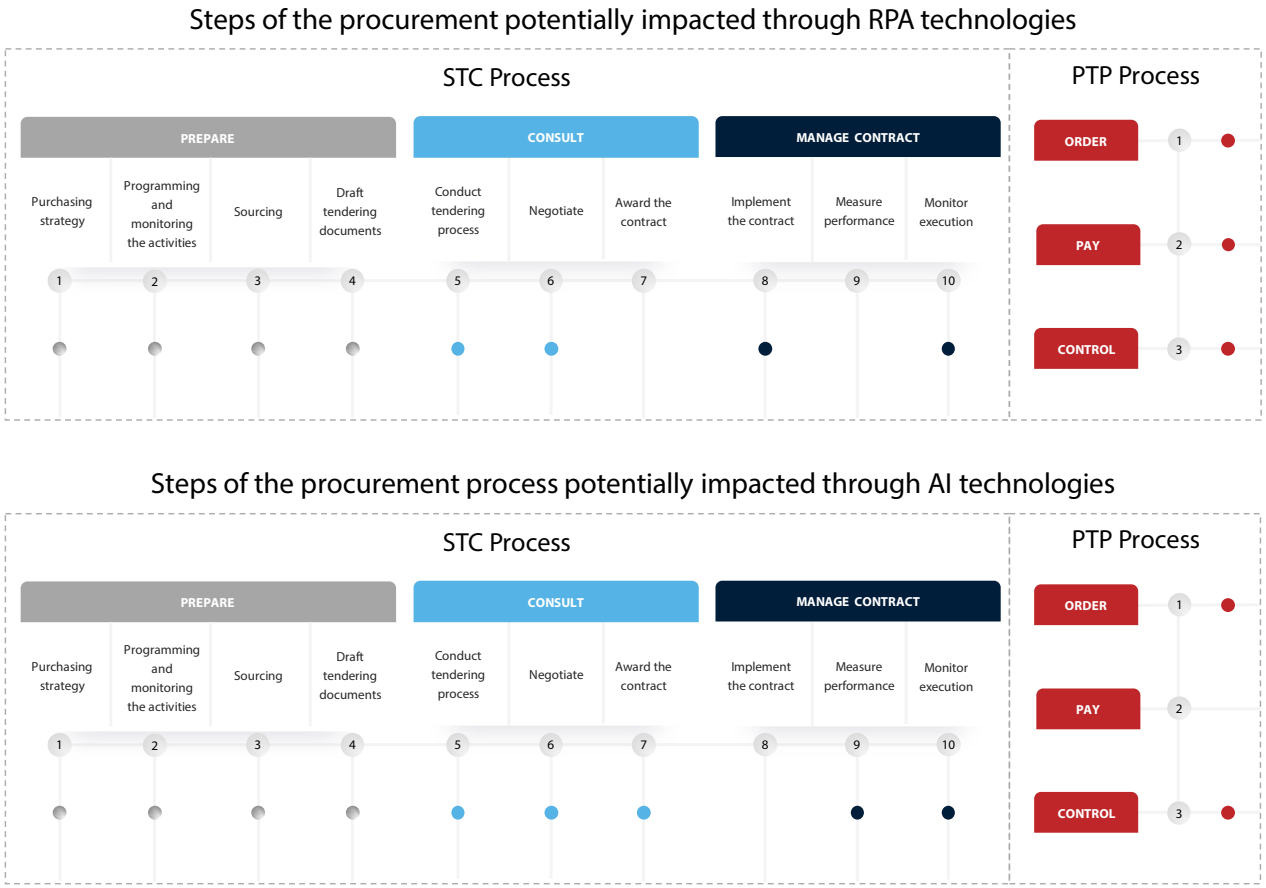
Enhanced contract management

- AI and RPA may offer significant contract management features. such as:
  - Automated tracking of contracts used to collect on rebates, discounts, and penalties related to SLAs
  - Automated supplier scorecards executed by bots that will facilitate supplier management quality
  - Facilitated search and retrieval of contracts/articles

Improved accuracy of strategic decisions

- Procurement can provide better evidence-based options for decision making and improve the accuracy of strategic decisions. Open data culture and application programming interface (API) will further accelerate the development of solutions for sourcing, costs, prices, and value analysis. The real challenge of "augmented tools" would be to provide access to new data that can be analyzed and compared to existing data to generate exclusive information, while combining AI-powered solutions to also automate several tasks.

Figure 16. STC-Impacted Steps - RPA and AI



Toward more predictive analysis with machine learning (AI)

- Machine learning can already predict contract consumption and compliance, turn data into information, ensure that suppliers are financially viable and stable, and more. Predictive analytics will be boosted through machine learning and NLP techniques, which are both AI fields. With AI, decision-making tools that go further than just presenting insights can be envisioned. AI will enable procurement professionals to have access to new exclusive insights and predict the outcome of certain potential business decisions. The use of specific algorithms will also give decision-making tools the capacity to provide hyper-personalized recommendations.

Toward automation of more critical STC tasks with AI

- AI-based technology allows for the automated recognition of given features within submitted bids so that it can increase treatment capacity when evaluating those bids. It could also lead to an automation of the due diligence process for critical contracts or suppliers. Indeed, bots could detect risk factors by analyzing the data associated with existing contracts and then call for further information to score each risk factor and provide a general risk indicator.

2. **Complementary benefits of RPA and AI technologies (shipment, invoice processing, spend management, etc.)**

N.A.

3. **Compliance and positive externalities**

- Until recently, there were limited examples of positive externalities generated by AI implementation in the tendering process. In one such example, in Ukraine, Transparency International launched an AI-based solution to assess

the likelihood of corruption risks in public tenders. Since 2018, the algorithm has helped detect more than 20,000 irregularities in procurement practices throughout the country (see chapter VI, case #9).

- AI could detect, during the sourcing phase, qualified SMEs that would not have been identified due to a lack of visibility. Another positive impact could be the automated recognition and scoring of contract features that benefit sustainable development.

4. **Risks: change management difficulties, regulatory barriers, and negative externalities**

- Jobs involving repetitive tasks, clerical work, and semi-skilled personnel could become redundant over time. Procurement professionals will have to be trained and learn to adapt to meet the needs brought by the transformation of the procurement process.
- More generally, the cultural change required could be difficult to implement in the public procurement sector, as it is often characterized by strict rules and well-established procedures. The transition should be accompanied by a suitable set of tools and training sessions.

5. **Mitigation measures**

- Mitigation measures are outlined in chapter V, where a number of good practices are presented to address the following risks:
  - Budget slippages
  - Scarcity of resources
  - Adoption issues

6. **Prerequisites**

- STC subprocesses and internal procedures must be clarified prior to RPA/AI implementation.
- Data related to procurement activities must be identified and classified, and the information's availability must be ensured.
- As reported by many decision makers across procurement organizations, automation of tasks through RPA should be implemented before developing AI solutions to ensure productive change management. This also makes sense from a technological point of view, as AI may enhance the comprehensiveness and reliability of these automized procedures.

7. **Balanced scorecard**

- See Figure 17.

GEOTAGGING AND GIS

GIS and geotagging technologies have recently penetrated a large number of fields of activity, even if their use **is still not widespread within public procurement organizations. However, they carry interesting innovative**

Figure 18. STC-Impacted Steps - GIS and Geotagging

Steps of the procurement process potentially impacted through GIS technologies

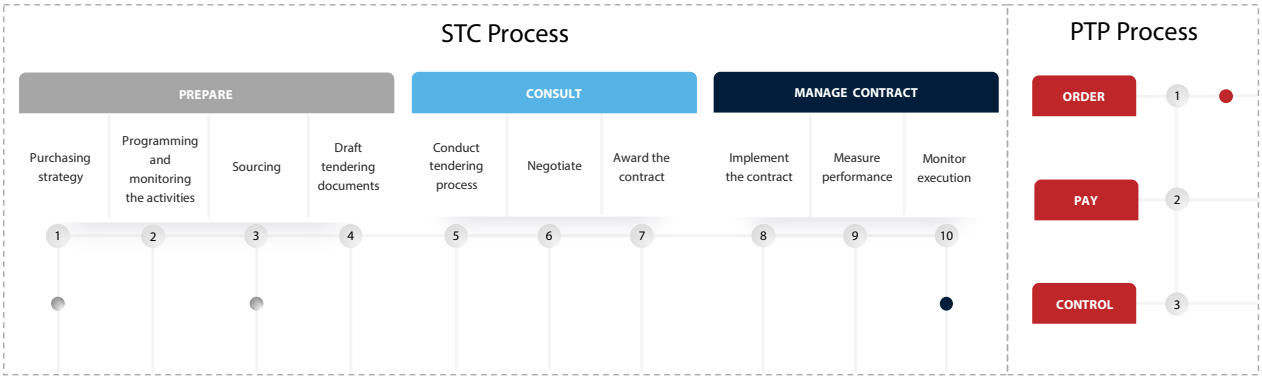
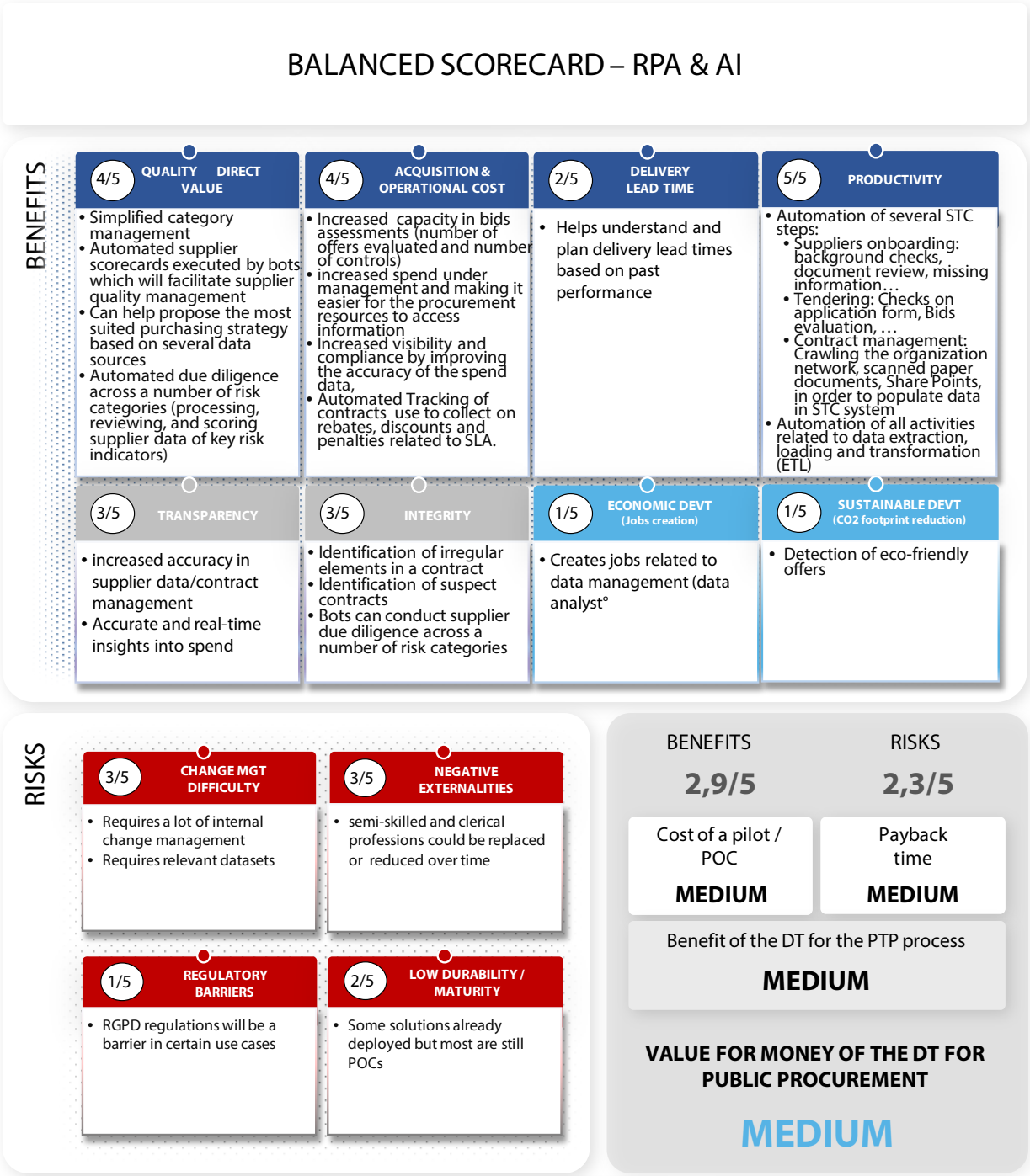


Figure 17. STC Balanced Scorecard - RPA and AI



Use cases
- New South Wales Procurement (Australia): Spend analysis over 150+ Government agencies (80M+ transactions)
- Federal Acquisition Service (USA): Faster processing time of suppliers offers and details
- DOZORRO artificial intelligence to identify trickery in public procurement (Transparency International, Ukraine)

Prerequisites
- SaaS e-procurement system (including e-billing) implemented
- STC sub-processes and internal procedures clarified
- Available data related to Procurement activities

Related technologies & software
- Big data
- Process mining
- ETL
- STC Systems (SaaS)

features for several phases of the procurement process, such as the definition of the strategy, the preparation of an RFP and RFQ, and the management of contract execution.

1. **i. Direct benefits**

GIS-based data can help define purchasing strategies and improve tendering documentation.

- The use of GIS can help clarify requirements upstream of the tendering process, in terms of both nature and volume. For example, for an infrastructure project, data collected through GIS technologies can provide valuable information on the nature of the local soil at the present date, which allows for a faster definition of needs and requirements. This data (in the form of a map) can also be embedded in tendering documents so that potential suppliers best comprehend the existing situation and are able to ask relevant questions during the tendering process. When it comes to estimating quantities expressed in volume or in area (for example, for construction, cleaning, or landscaping contracts) and to submitting an RFQ, collecting data through GIS technologies can save a lot of the time and the money usually spent on studies and measurements in the field.
- In England, the Westminster City Council has embedded maps generated by GIS tools into its tender documents for new waste collection contracts and more closely considered bids from contractors with sites within a delineated 35-minute drive-time area. This has helped save costs and CO2 emissions (see chapter VI, case #10).

Once contracts are signed, GIS is of great benefit to help assess the supplier's performance and to prevent undesirable events.

- GIS technology may be an interesting means of verifying the fulfillment of contract objectives and detecting malpractice. For example, combined with remote sensing, it makes it possible to track the material flows or to control delivery frequencies. Moreover, it can provide interesting information on the completion of stages and thus the progress of an ongoing project, which is of particular interest for infrastructure plans, such as a road construction, for example. It may thus help assess supplier performance by giving a geographic representation of its activities.
- In addition, this data may be used to create automatic alerts when a critical project turns out to be harmful for people in the area or for the environment. The technology can consolidate measurements of noise pollution from multiple geographic points, for example, and give a precise indication of their origin. Furthermore, all of this data may be saved and reused to feed future purchasing strategies for similar projects.
- Finally, this data could also fuel some public portals dedicated to enhancing taxpayer influence on public procurement and expenditure decisions. Citizens themselves could report by means of those portals that a recently built road has deteriorated, for example, or that public lighting does not work in a certain place. This could both improve the efficiency of contract management and involve more citizens in public spending options.

2. **Complementary benefits of GIS technologies (shipment, invoice processing, spend management, etc.)**

- GIS implementation benefits of the PTP process include:
  - In LICs or MICs, GIS can be used to map the "secondary" road network ("dirt roads"), classify them in terms of travel speeds, and map the transportation hubs and resources. As an example, the Tanzania government (in partnership with the U.S. Agency for International Development [USAID]) used these features to analyze delivery routes to local health facilities. It helped to build up a clear understanding of drive times, depending on the different seasons. In the end, GIS made it possible to guarantee that every line and every facility was connected to the digital

road network and make health commodity deliveries in Tanzania more predictable and efficient.

- Most sophisticated GIS applications can model the movement of cars and trucks. GIS can then be used to analyze the traffic and to identify the most efficient delivery routes during rush hour or deduce the most appropriate delivery timetables (i.e., the ones that minimize drive times, costs, and pollution emissions). Tracking solutions help people monitor the location and movement of objects in real time and can therefore respond to the requirements of efficient logistics management. By GPS or a similar technology, objects can be dynamically tracked on a map that can be shared through the internet or intranet.

3. **Compliance and positive externalities**

- One important advantage of GIS technologies is that they make the movement of people superfluous, whether for assessing needs or for checking project advancement. As such, they may contribute to the reduction of the CO2 footprint.
- As already mentioned, GIS can contribute to enhance citizen involvement in the decision making of public organizations, which can make procurement activities more transparent and equitable and contribute to hold local stakeholders accountable.
- Digital road networks or specific maps can be uploaded onto OpenStreetMap so that they benefit the population and are accessible for other uses.

4. **Risks: change management difficulties, regulatory barriers, and negative externalities**

- As with the IoT, GIS is a mix of technologies that might be costly and complex to implement: consulting services, system infrastructure and software, application development services (custom application design and development, integration of GIS with external systems and databases), database development products and services (GIS database design, map conversion services), technical implementation and operational support, and purchase or licensing of GIS datasets.
- The cost of spatial data depends on the country and may be very high in some parts of the world.
- The use and diffusion of spatial data are regulated by national governments, which apply different criteria to the data's delimitation. Even if GIS is generally provided by actors that already comply with local regulations, it may be important to determine whether the chosen actor is approved in the country before initiating a contract, not least because the use of spatial data without the owner's permission can lead to copyright violations and legal consequences.

5. **Mitigation measures**

- Mitigation measures are outlined in chapter V, where a number of good practices are presented to address the following risks:
  - Interoperability between subtechnologies and components of the target system
  - Reversibility and dependency issues
  - Budget slippages

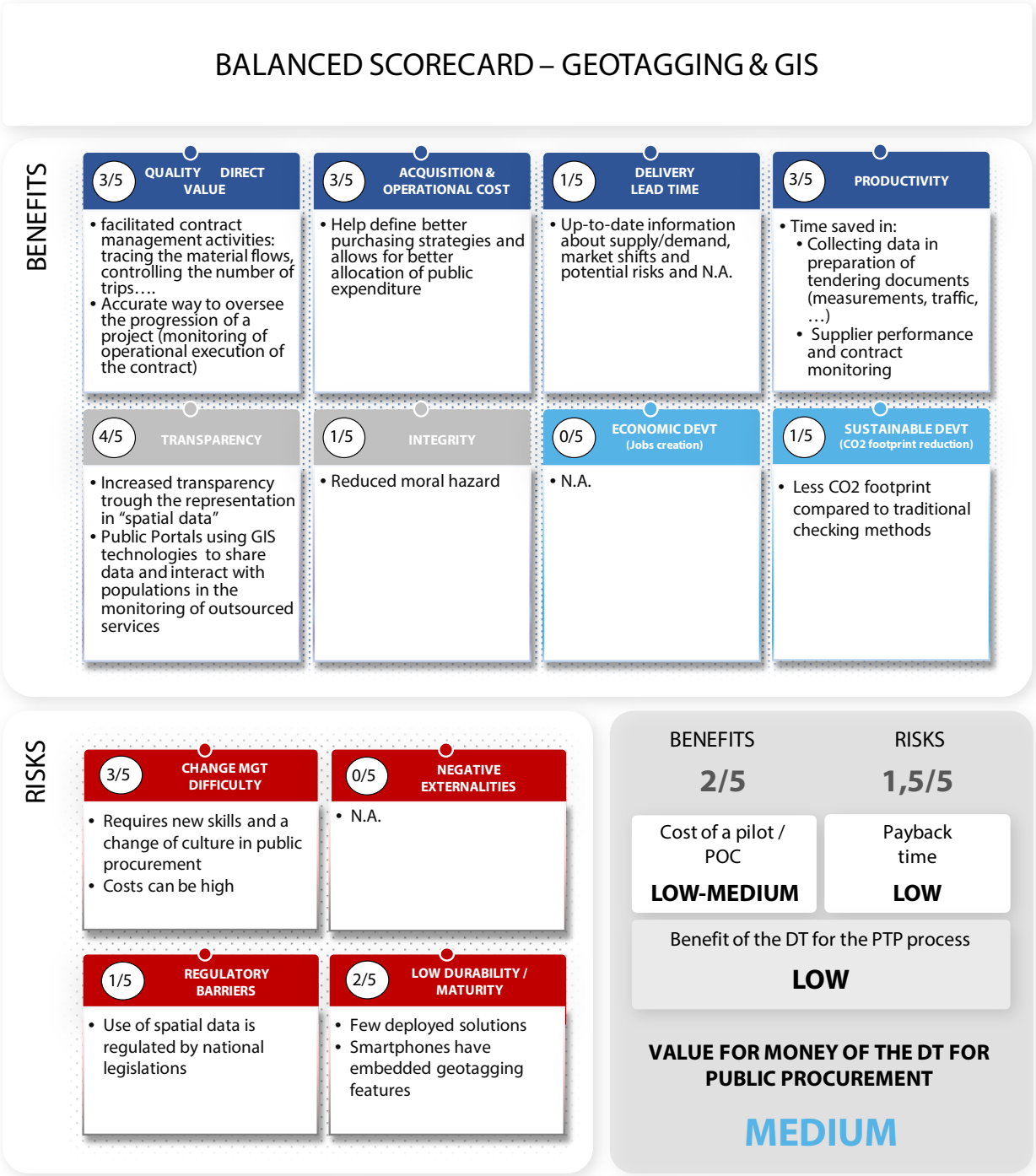
6. **Prerequisites**

- A high bandwidth is required, as users with a slow internet connection will have difficulty loading maps and data, which can be frustrating. GIS often must be combined with other new technologies to provide precise and readable data. For example, AI should help the system identify specific information on a map, or the IoT often produces measurements that are geotagged and then consolidated on a broader scale by GIS technologies. It is important to specify all the software, hardware, and skills required for the identified needs.

7. **Balanced scorecard**

- See Figure 19.

Figure 19. STC Balanced Scorecard – Geotagging and GIS



Use cases

- Westminster city council (England) – Waste disposal contracts
- Ministry of Rural Development (India) – Monitoring of agriculture assets to bring in transparency and authenticity.

Prerequisites

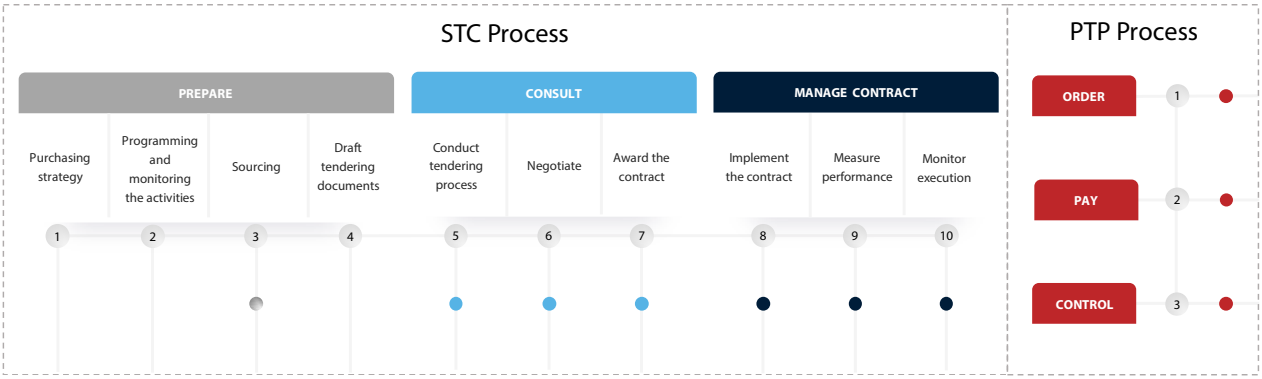
- Potentially, access to remote sensing data
- Permanent internet connection

Related technologies & software

- AI
- Remote sensors & IoT
- Drones

Figure 20. STC-Impacted Steps - Blockchain

Steps of the procurement process potentially impacted through blockchain technologies



BLOCKCHAIN

Blockchain is an efficient system for recording transactions, as all the relevant stakeholders maintain a level of equality and access in tracking procedures (the concept of "immutable and decentralized ledger"). This technology has the potential to ensure secure and transparent tender bidding actions as well as more efficient contract management. Nevertheless, very few public organizations have so far succeeded in making a move from trials to fully production-ready blockchain related to public procurement. Some serious technical obstacles (see subsection iii on risks below) remain and it is not likely that this technology will develop significantly in STC activities in the near future.

1. **Direct benefits**

- **Blockchain provides a clear channel that ensures that all stakeholders behave according to legislation during the tendering process.** Goals pursued by the early adopters of blockchain include the ability to evaluate offers without having to go through a trusted third party that encrypts them.
- A blockchain tendering system implies smart contracts. A smart contract is an agreement between two people in the form of computer code. Smart contracts are a software program that runs automatically, using information guaranteed by the blockchain to be correct. Therefore, manual checking of bids by third parties can be avoided, significantly lowering processing costs and lead times:
  - The contracting authority creates a tender as a smart contract and places it on its private blockchain (or "permissioned blockchain"). The code of the smart contract, showing how the bidding evaluation will be conducted, is accessible to all parties and unchangeable. It is then impossible for the tendering organization to change information or modify the evaluation criteria.
  - A bidder can then download the smart contract tender from the blockchain and prepare its offer and subsequently place an encrypted bid. This fully guarantees confidentiality and certainty that third parties cannot bid on behalf of other organizations. Bidders do not know and cannot view the other companies that have placed a bid or see how much they have proposed.
  - When the bidder sends its bid as a smart contract to the blockchain system, it is signed through the bidder's certified key signature (which is provided by the public organization during the initial registration process).
  - Upon the RFQ/tender deadline, the smart contract automatically stops accepting new bids.
  - The contracting authority can

download and decrypt the bids. The bid assessment is done through the smart contract (computer-run evaluation) to ensure equal treatment for bidders.

- Finally, the results are then sent to the blockchain and published. The contracting authority is unable to access the bids once the "blockchain tender" is closed and the awarded contract entity is published on the system. Since the blockchain makes the data immutable, the entire bidding process can be independently audited based on public information. The details of the tender and the bid evaluation scale can be viewed by citizens and downloaded as part of an evaluation to ensure the fairness of the tendering process. This makes blockchain a **promising tool for detecting fraud risks and fighting corruption.**

- Blockchain drastically increases project auditability through comprehensive audit trails on the part of both suppliers and buyers. That was the primary goal of, for instance, the Seoul district of Yeongdeungpo-gu in South Korea when adopting the technology:[9] recording the results of the individual evaluations because the tendering decisions to award contracts were often contested by the losing competitors.

- In 2016, motivated by the drive for open governance, the University of London published a paper outlining the possibilities for blockchain in public tenders.[10] The main idea was to prove the potential of blockchain and smart contracts to enable a citizen overview of government activities with a reduced budget. The initial suggestion was for a government tendering process. The system would bring fairness through immutability, privacy protection, and the prevention of third-party bidding.

- To prevent corrupt practices, the paper suggested a three-part approach, all of which can be achieved by blockchain:

  1. Once a tender is published it cannot be altered, thus removing the possibility for criteria alteration to match one of the bidders.
  2. Bidding must be done confidentially so other applicants are not provided with amounts or detailed information. Furthermore, bids must be tamperproof so that both bidders and corrupt officials are unable to alter details or proposals for a preestablished objective.
  3. As a last step, the body responsible for publishing the tender can evaluate the bids only after the whole tender process has been sealed.

- As shown by some current initiatives in the private sector, blockchain could help to optimize and secure the tendering process for public tenders as well, in particular by guaranteeing the authenticity of the documents transmitted by candidates and tenderers. By building a secure blockchain network, the purchasing organization could automate in real time the validation of references, certifications, and audit reports transmitted by the bidder. This could bring valuable benefits, particularly by validating the authenticity of the most critical certifications and licenses. In addition, the documents supplied are by nature continuously accessible to all members of the network, thus avoiding the need for suppliers to transmit the same documents several times to each purchasing entity.

[9] "Glosfer's Blockchain-Based Proposal Evaluation System Wins Seoul Government's 'Best Anti-Corruption Practice Award,'" EIN Presswire, November 14, 2018, https://www.einpresswire.com/article/468151864/glosfer-s-blockchain-based-proposal-evaluation-system-wins-seoul-government-s-best-anti-corruption-practice-award.
[10] F. S. Hardwick, R. N. Akram, and K. Markantonakis, "Fair and Transparent Blockchain Based Tendering Framework - A Step Towards Open Governance," May 15, 2018, https://www.researchgate.net/publication/327479167_Fair_and_Transparent_Blockchain_Based_Tendering_Framework_-_A_Step_Towards_Open_Governance.

- In Spain, the Aragon region introduced a new tendering solution in June 2019 securitized by blockchain to evaluate offers without having to go through a trusted third party that encrypts them. The project objective was to eliminate bribery and other corrupt practices in the tendering process, particularly in the awarding of small contracts (see chapter VI, case #13).
- In addition to building trust in the tendering process, usage of "blockchain tender" may also lead to cycle time reduction through improved document flows. Tendering efficiency is also reinforced as roles are clearly defined and assigned to all stakeholders within the blockchain, and the approval/signature procedures are simplified during the tendering and award process (on both the supplier and buyer side).

Blockchain may offer increased capacity in contract management

- Another interesting application of blockchain is in the contract management process. Indeed, building a blockchain-based network that includes every stakeholder could help verify whether contract execution fulfills all requirements. For example, this might allow for an authentication of acceptance reports in real time or the elimination of counterfeiting risks in document-validation procedures.
- Certifying the supplier's information during the execution phase through a public or permissioned blockchain by vendors would increase the sincerity of the offers and therefore help buyers make better choices. More precisely, the monitoring of contractual commitments could be automized: if a condition, such as time delivery, has not been met, related penalties would be triggered automatically without need of a third party, which may significantly reduce transaction costs.

2. **Complementary benefits of BCTs (shipment, invoice processing, spend management, etc.)**

- **They are a single and integrated source of truth for supplier and purchasing order/invoice data.** A permissioned blockchain avoids the need to maintain two copies of the same transaction by the client and the supplier (whether in paper or electronic form). Order, delivery, and payment details are stored in one ledger of the blockchain, which is then duplicated and distributed across the entire network of computer systems. Additionally, documents cannot be tampered with or modified. For instance, there is no need for the customer to check that the terms of the purchase order signed by the supplier have not been changed, as the digital ledger guarantees that the document is tamperproof.
- **Smart contracts may transform the entire procurement process.** Smart contracts are pieces of code running on a blockchain network that can verify their conditions themselves and self-execute. They can therefore eliminate paperwork and the uncertainty of trust between the parties while they are streamlining the different approval steps of the procurement process. They can, for instance, auto-execute a payment once the contract's preagreed criteria, based on the receipt and purchase order data, are sent to blockchain. The execution of the conditions at each stage are recorded against the contract and fully visible to the permissioned blockchain network. Smart contract implementation for PTP does raise certain questions, however:
  - Smart contracts are not modifiable once deployed, and the outcome of their execution cannot be reversed. In the event of an unexpected change, a register must be recreated, and the smart contract must be run again.
  - Even though smart contract programs are often open source, their design is delicate. Programming smart contracts requires thinking from an economic perspective that most programmers do not initially see.

On their side, buyers must be able to specify the ramification of controls and the different variables to a computer specialist who then transcribes it into code. This ability to specify, model, and forecast different scenarios is a new skill to be acquired within the purchasing team.

- **Permissioned blockchain improves authentication and validation.** BCT can enable the quick distribution of authentication rights along the PTP chain, helping to prevent fraud and improve security (as was already seen in the impact of blockchain on STC).
- **Blockchain is used to automate the process of material inventory/reception.** Blockchain systems' ability to provide a secure and reliable architecture to transmit information and its application to the supply chain network can have many advantages. Companies and public organizations working together can use a blockchain system to record data on the location and ownership of their materials and products. All members of the supply chain can see what happens in real time as resources move from one entity to another. Since the data records cannot be changed, it eliminates the need to determine the current owner or the responsible party in the event of a problem.
- **The technologies help with product provenance certification.** Some interesting initiatives have emerged to certify the origin of the finished product (by Walmart in the food industry, for example, and BMW in the automotive). Blockchain can certify the manufacturing plants through which the product has transited, and also provide information on the location of the suppliers who have provided the various raw materials. Blockchain could guarantee public buyers that they have acquired an authentic product that respects the specified certificates and qualification statuses and the ethical charter.
- **Smart contracts can lower the administrative frictions in custom-related activities.** Permissioned blockchain is already used to facilitate cross-border transactions. It ensures that every party to a shipment has access only to its information, thus reducing unproductive exchanges on freight/customs-related issues. Some authorities and agents in charge of the import and export of goods already digitize customs clearance data and document workflows through a "blockchained platform" that interconnects cargo owners, ocean and inland carriers, freight forwarders and logistics providers, ports and terminals, and customs authorities (such as the TradeLens platform launched by MAERSK[11]).

3. **Compliance and positive externalities**

- Since most of the existing encryption technologies required for bidding are currently complex or costly to use, and as such, deter many small businesses from taking part in public tenders, a simplified and automized encryption of supplier data might be of significant benefit to foster equity among potential suppliers in the tendering process.
- With real-time and precise information about the flow of materials and products, blockchain networks can help prevent theft and waste along the supply chain.
- Replacing traditional signatures by approvals encrypted by blockchain also makes it possible to reduce paper consumption.

4. **Risks: change management difficulties, regulatory barriers, and negative externalities**

Scalability issues

- One important threat to the application of BCT in public procurement is the volume of tendering transactions that are processed each day. Since each

[11] For more information, see https://www.tradelens.com/platform.

blockchain-based transaction has to be validated through a large number of nodes, tendering and contract management processes could imply very high transaction times. By way of comparison, the current target time for the validation of a block on the Bitcoin network is 10 minutes. "Response times" will all depend on the number of transactions and users and the complexity of the consensus algorithms that are implemented.

- Since all "nodes" hold a copy of the blockchain, scalability issues also arise in terms of the total amount of data that can be stored. One may wonder whether public chains can store and handle the volume of data involved, all the more so as calls for tenders contain numerous documents, appendices, maps, plans, and so on. Public blockchains may not viably store such large amounts of data. Another issue would be the ability of smart contracts to manage the complexity of evaluation criteria in public tenders. Are smart contracts smart enough?

Lack of skills and technological partners for large-scale implementations

- Although developers can easily build blockchain-based networks and start developing solutions on top of them for POCs (most of the BCTs are open source), bringing them to production is challenging. BCTs do not offer the possibility of lightweight implementation upon legacy systems; rather, sophisticated skills and a significant amount of money are required to set up the initial blockchain infrastructure.

Costly projects

- Projects can be costly (especially if the current system is totally replaced) and complex when it comes to assimilating the existing system with blockchain features.

Regulations

- Regulators in different countries are currently developing guidelines and "guardrails." One of the questions raised by jurists and legislators is the usage of the 64-digit alphanumeric key called private key or wallet, which allows for anonymous transactions. This obviously reduces transparency and regulators' ability to have oversight. In order to address the regulatory need for verified identities, authenticated business or individual identity data must be linked to each blockchain public key.

Security risk on private blockchains

- A risk of piracy exists, as revealed by the cryptocurrency experience. Among the different intermediaries that have emerged to facilitate the management of cryptocurrency portfolios, some have turned out to be fraudulent. Moreover, public keys and other personal data are stored outside the blockchain and are not subject to the same security protocol as in the blockchain itself. By analogy, there have been hundreds of millions of euros lost due to hacks, or because a user lost his private key or had it extorted, or had his hard drive stolen. In total, one-fifth of initially emitted Bitcoins are currently missing.

Risks on external data from the blockchain

- In the same way, smart contracts, or codes that trigger automated actions on a blockchain, in particular on the Ethereum Blockchain, use external data. But this external data has to be secured as well, and the developed solutions will have to ensure that data will be appropriately entered.

5. **Mitigation measures**

- Mitigation measures are outlined in chapter V, where a number of good practices are presented that address the following risks:
  - Interoperability between the subtechnologies and components of the target system
  - Reversibility and dependency issues
  - Procurement complexity and difficulty in specifying

- Budget slippages
- Scarcity of resources
- Adoption concerns

6. **Prerequisites**

- Since blockchain implies the continuous replication of storage and movement of data, high connectivity is required to ensure its viability for the public procurement process. Stakeholder skills and hardware facilities must be conducive to the deployment of new digital technologies as well; for example, a blockchain registry may not be of real benefit in countries where suppliers are not used to conducting digital transactions.
- If the digitization of procurement procedures has not yet been fulfilled, it is recommended that the process begin with the implementation of cloud computing technology, which offers comparable advantages. Blockchain can then be revisited as a second step.
- Blockchain must be combined with other technologies to be fully profitable. Generally speaking, the blockchain alone is not able to offer an operational solution for digitizing the PTP process. For instance, it must be integrated with SaaS platforms to allow for the monitoring of KPIs and the management of notifications and follow-up on authorized members. The blockchain also benefits from being linked to the RPA, which will be able to use the data "validated" by the blockchain but also to supply the smart contracts with external data. This then raises another question, which is discussed below: what is the cost of making the blockchain interoperable with these complementary technologies and how complex would the process be?

7. **Balanced scorecard**

- See Figure 21.

REMOTE SENSING AND THE IOT

A significant number of public authorities are already using smart technologies. For example, as one of the flagship technologies for "smart cities," these new systems are used to control the safety level of public transportation. That said, public buyers have not yet really grasped the technologies in their day-to-day actions. Even if buyers still have little use for IoT technologies, the potential of analyzing data provided by connected objects is significant, in particular for the "prepare and contract management phase."

1. **Direct benefits**

Public buyers can potentially leverage the IoT on the STC process.

New types of analyses/findings

- The IoT enables decision makers to better understand equipment procurement and usage, plan for user needs and

Figure 22. STC-Impacted Steps - IoT and Remote Sensing

Steps of the procurement process potentially impacted through IoT technologies

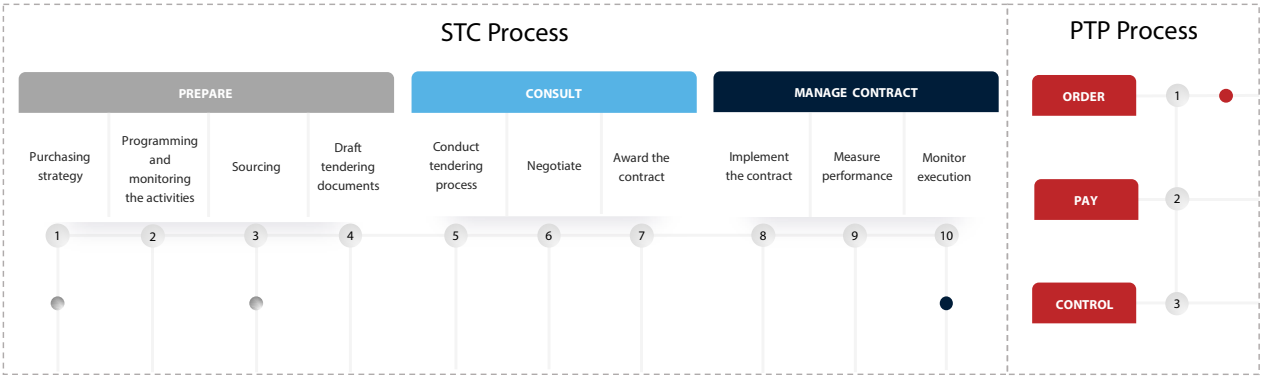
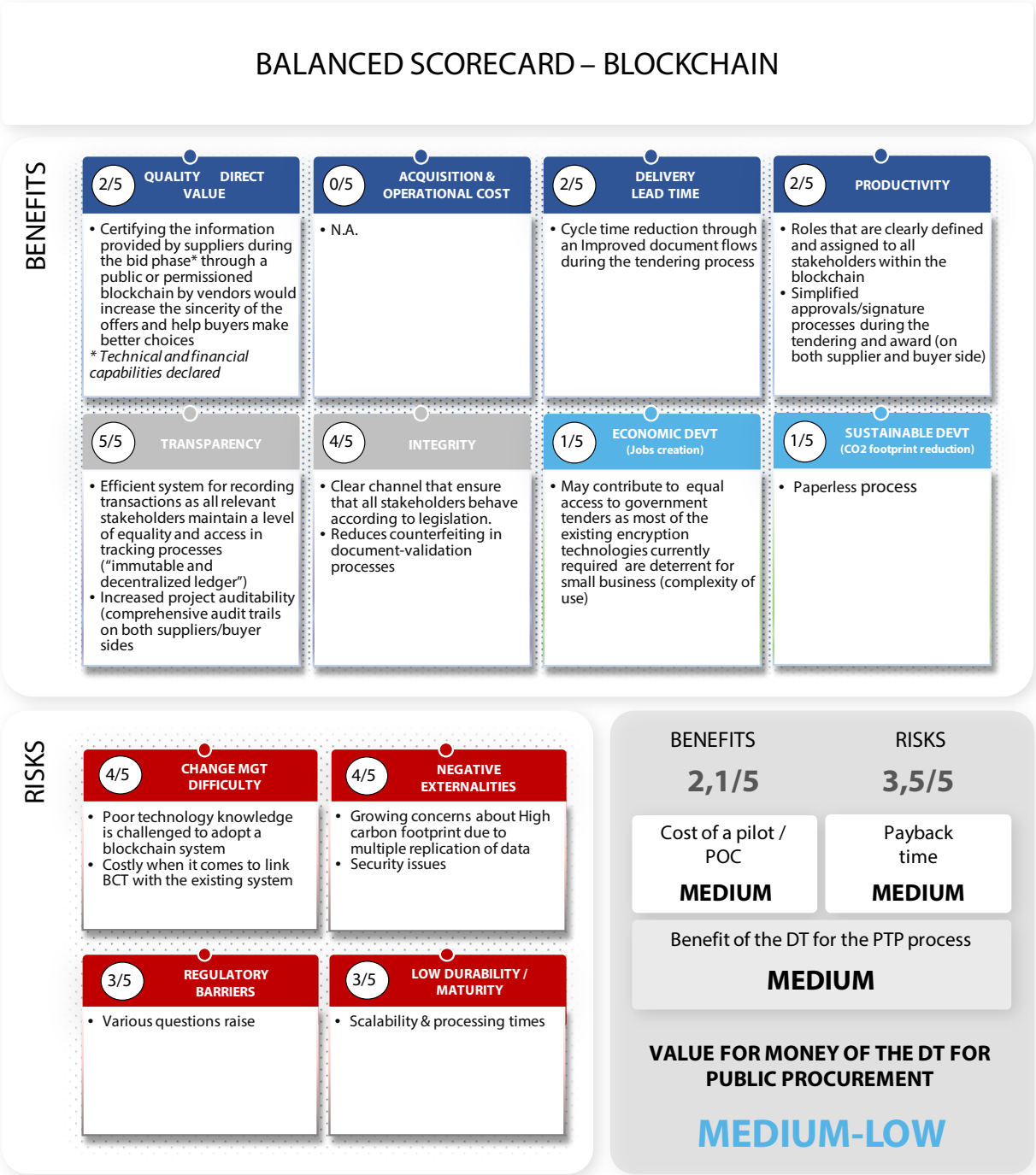


Figure 21. STC Balanced Scorecard – Blockchain



Use cases
- Department of Health and Human Services (USA) – Blockchain used to layer over the existing contract systems
- Region of Aragon (Spain) decision to leverage blockchain to stamp out illegal activities.
- The district of Yeongdeungpo-gu (South Korea) – creation of a transparent and trustworthy system for the evaluation of public tenders
- Winner project of the "Blockchain HACKMX" hackathon (Mexico)

Prerequisites
- SaaS e-procurement system (including e-billing) implemented
- STC sub-processes and internal procedures clarified
- High connectivity

Related technologies & software
- SaaS e-procurement systems (including e-billing)

habits to make more informed decisions and develop more robust procurement strategies. It allows for new types of analyses and findings that were previously not possible at the buyer level: usage rate and energy consumption for different equipment, usage behaviors, peak usage periods, number of staff circulating in the premises according to work shifts, and so on.

- In some cases, the IOT might also facilitate RFP preparation through automated collection of sensor data (consumption, location, usage). Coupled with traditional data sources, the IOT can give an interesting picture of the situation to the different vendors participating in a tender and reduce the time spent collecting data in order to prepare the specifications.

Real-time insight for more rapid actions

- Sensors offer real-time information as long as the equipment is kept in good repair, providing the ability to identify/anticipate equipment faults and stoppages in real time. This allows a procurement department to respond to issues more promptly and accurately. For instance, the IoT can trigger an alert when a critical piece of equipment has reached a specified number of cycles or threshold, from which point a replacement must be considered and prepared with internal stakeholders. The goal is to prepare before the failure, or the stoppage actually happens. This adaptability is quite appreciable in view of the average length of public tendering procedures (counted in months).

Facilitated monitoring of SLAs

- In contract management activities, especially facility management contracts, the IoT presents interesting opportunities to control compliance with SLA standards. Based on data provided by sensors, contract managers may, for example, be able to check the frequency of maintenance operations or to detect overconsumption of energy by a service supplier. This data can then be used to generate alerts that could prevent undesirable events from occurring, or the data can be consolidated and fuel analyses to help establish future procurement strategies. For example, as reported in the use cases (see below), in Belgium, remote sensors can allow public buyers to monitor temperature and humidity levels in public premises (as one of the key indicators that the provider must maintain) or to organize the collection of refuse when the recycling bins are full.

2. **Complementary benefits of IoT technologies (shipment, invoice processing, spend management, etc.)**

More accurate warehouse management.

- IoT-enabled warehouse systems may help procurement teams identify and control supply levels through real-time updates on inventory and location. Another application is IoT-enabled product shelves (smart shelves) that are only just emerging for use in the retail industry. A smart shelf can track all items placed on it and therefore provide information on the availability of products on the shelves, which can help personnel to immediately refill the stocks that are in short supply. Orders can be made automatically for certain items to ensure that they are not out of stock.

Estimation of demand and supply through a combination with AI.

- Algorithms developed using computerized AI systems may be able to track and manage inventory very accurately. By analyzing IoT data, the AI system can detect patterns that a person might not notice. This process can improve inventory management decisions and order scheduling.

Optimized shipment tracking.

- When the IoT is combined with GPS systems, it is possible to track transportation and more accurately understand how close a cargo is to a given location. Radio frequency

identification (RFID) technology can also be used to locate specific items on a pallet, allowing recipients to unpack the most needed items first. In addition, organizations could potentially use RFID to track such goods as equipment throughout a supply chain. It can also help better harness the risk of theft during the receiving process and other warehouse functions, thus reducing the number of stolen goods and subsequent downstream consequences, for example, from stalled production on a construction site.

3. **Compliance and positive externalities**

- When smart objects are well implemented, they not only provide data and alerts on undesirable events but also give information on the cause. One interesting illustration is the installation of connected sensors in various parts of vehicles, which have already been put in place by some car and truck manufacturers. The technology gives in real time both a measure of fuel consumption and an evaluation of the efficiency of the various vehicle components, depending on whether the pressure sensors have been installed in the engine cylinders, in the particle filters, and so on. Application on a larger scale can better monitor compliance with environmental standards and allow suppliers and buyers to agree on action plans to best meet their requirements in this area.

4. **Risks: change management difficulties, regulatory barriers, and negative externalities**

Significant technical as well as nontechnical issues

- Developing and using suitable IoT-based solutions can be costly, since personnel dedicated to data processing and integration must be hired and/or trained. There are also costs related to the development and maintenance of the appropriate software. What is required is a mix of instrumentations, a communication network, software, data storage tools, and data management consultants. This is why many governments do not establish in-house capabilities but rather contract with universities or specialized companies to get data that are suitable, readable, and reliable. In order to minimize risks, it is better to start small with pilot projects and invest progressively according to the roll-out plan.
- Security continues to be another drawback to these solutions, since 86 percent of local governments in the United States have already experienced a security breach related to the IoT.[12] A combination of hardware and software encryption tools is required to ensure the security of the hosted data, data in use (made accessible to IoT devices), and "in-flight data" (data sent to the cloud).
- Another important issue to consider is the legal framework that limits access to and the use of personal and private data. As these frameworks vary between countries, solutions cannot be implemented according to a uniform method. As such, the participation of legal counsel in such projects is highly valuable.
- There is no clearly established preferred standard, either in terms of method or technology. The risk of adopting the wrong approach is high, as feedback is still rare among procurement actors.

5. **Mitigation measures**

- Mitigation measures are outlined in chapter V, where a number of good practices are presented that address the following risks:
  - Interoperability between subtechnologies and components of

[12] ECSO, "Smart Cities and Smart Buildings Sector Report: Cyber Security for the Smart Cities Sector" (Brussels: European Cyber Security Organisation, 2018), https://www.ecs-org.eu/documents/uploads/smart-cities-sector-report-032018.pdf.

the target system
- Reversibility and dependency issues
- Procurement complexity and difficulty in specifying
- Budget slippages
- Scarcity of resources
- Adoption concerns

6. **Prerequisites**

- In addition to the technical prerequisites, it is necessary to define a purchasing strategy that ensures the coherence and interoperability of the technological bricks between them.

7. **Balanced scorecard**

- See Figure 23.

DRONES

The main impact of drones is related to the way the service or product can be delivered. The use of **drones can significantly accelerate and secure the delivery of critical supplies to public organizations, especially in the health care sector.** For instance, the Ghana Health Service (use case described below) has adopted drones for the delivery of pharmaceutical products to locations in a range of 80 kilometers from the main hospital. This will significantly improve performance in rural areas, increase the availability of products, and save lives. In addition to its impact on the overall strategy and supply chain of selected items, drones offer interesting benefits for contract execution and management.

1. **Direct benefits**

Visual inspections are essential to various industries as part of the maintenance process. Drones can contribute to optimizing this process by reducing the frequency of physical inspections, which can be costly and time-consuming, for instance in oil and gas infrastructures, solar plants, railways, and so forth.

Drones offer interesting benefits for contract execution and management

- Drones provide opportunities to overcome geographic hurdles and may offer an enhanced level of detail to improve performance. For example, they can access remote areas or places that are difficult or impossible for humans to inspect.
- Moreover, they offer an economically advantageous alternative to the use of professionally manned aerial vehicles. Inspection capacities of drones already assist with follow-up contracts, whether the public organizations operate their own UAS fleet in-house or subcontract inspections to specialized service providers.
- In construction or major infrastructure projects, drones can be used to carry out surveys of the building process on a regular basis, usually daily or

Figure 24. STC-Impacted Steps - Drones (UAS)

Steps of the procurement process potentially impacted through drones

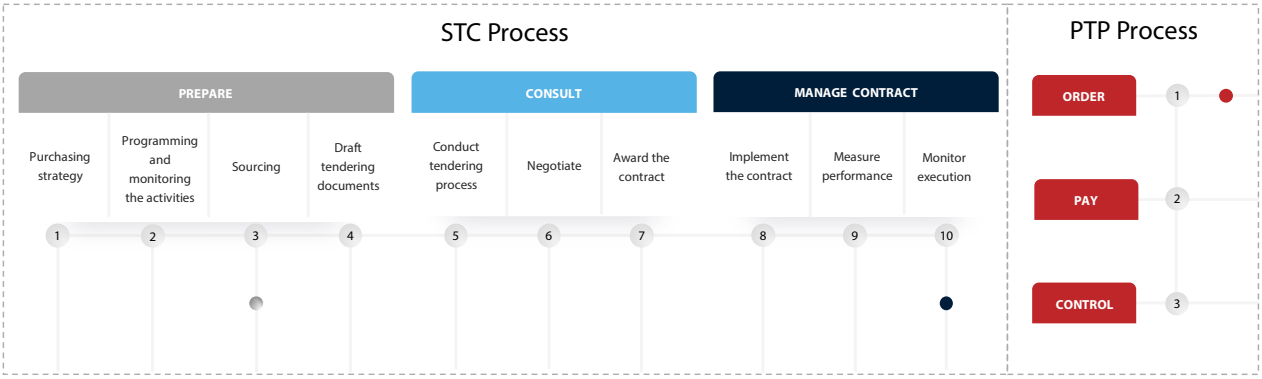
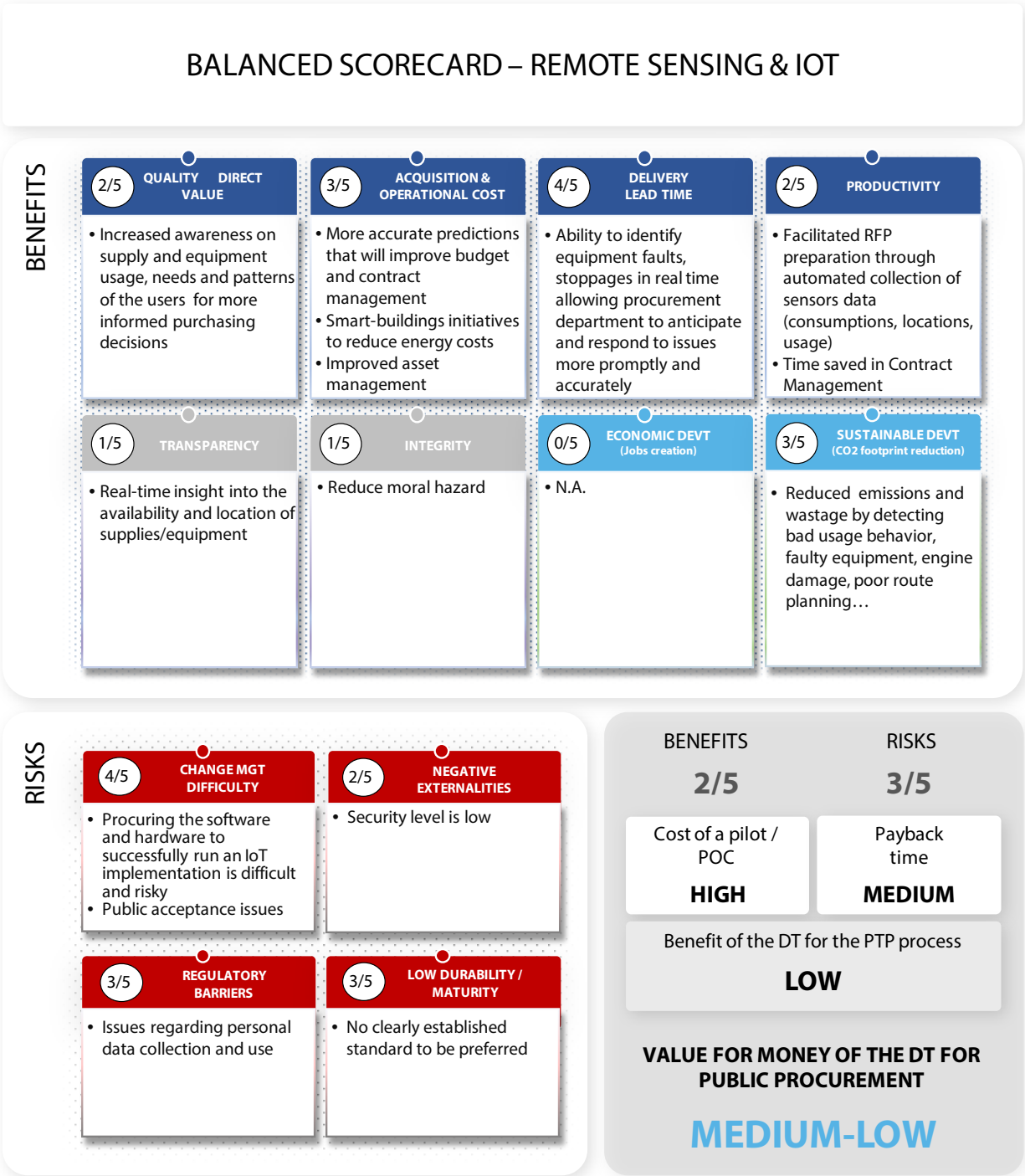


Figure 23. STC Balanced Scorecard – Remote Sensing & IoT



Use cases

- Sigfox: NRB monitors temperature and humidity levels in public premises (Belgium)
- Sigfox: NRB monitors the capacity level of recycle bins and organizes collection of refusal accordingly (Belgium)

Prerequisites

- N.A.

Related technologies & software

- Data Analytics
- AI

weekly, which leads to a more efficient consumption of resources dedicated to contract execution. They allow inspections to be conducted more frequently and improve diagnostics, since they are able to collect large amounts of data and obtain exhaustive readings on structures in a very short time. Drones also reduce the logistical resources that are needed for these operations and are less intrusive on their surroundings.

2. **Complementary benefits of drones (shipment, invoice processing, spend management, etc.)**

- Drones do have a growing impact on purchasing strategies as they bring new possibilities for the transportation of goods. Public purchasers, in particular, when located in remote or isolated areas, will increasingly consider this alternative to traditional delivery methods that are often costly and not secure.

3. **Compliance and positive externalities**

- The introduction of UAVs in the public procurement supply chain may foster the emergence of a new public service. This new mode of express transport could be used for the delivery of objects of limited weight.
- Drones contribute to better health care coverage.
- Drones have a smaller carbon footprint, since using drones instead of traditional vehicles for deliveries or inspections may allow for significant reductions in CO2 emissions.
- The use of drones should enable better communication with certain regions and help deliver goods to remote areas.

4. **Risks: change management difficulties, regulatory barriers, and negative externalities**

- The main risk associated with the use of drones is noncompliance with legislation to guarantee and respect citizen privacy. The specific legal framework depends on the jurisdiction and should be closely scrutinized, as the laws can rapidly change. For instance, in the United States, 40 states and 135 local governments have already enacted laws relating to public sector drone use.
- Further drone security issues have been reported, such as collision risks, drone hacking, or privacy concerns. Because of the risk of falling from the sky, their use is considered too dangerous in areas with a high population density.

5. **Mitigation measures**

- Mitigation measures are outlined in chapter V, where a number of good practices are presented that address the following risks:
  - Interoperability between sub-technologies and components of the target system

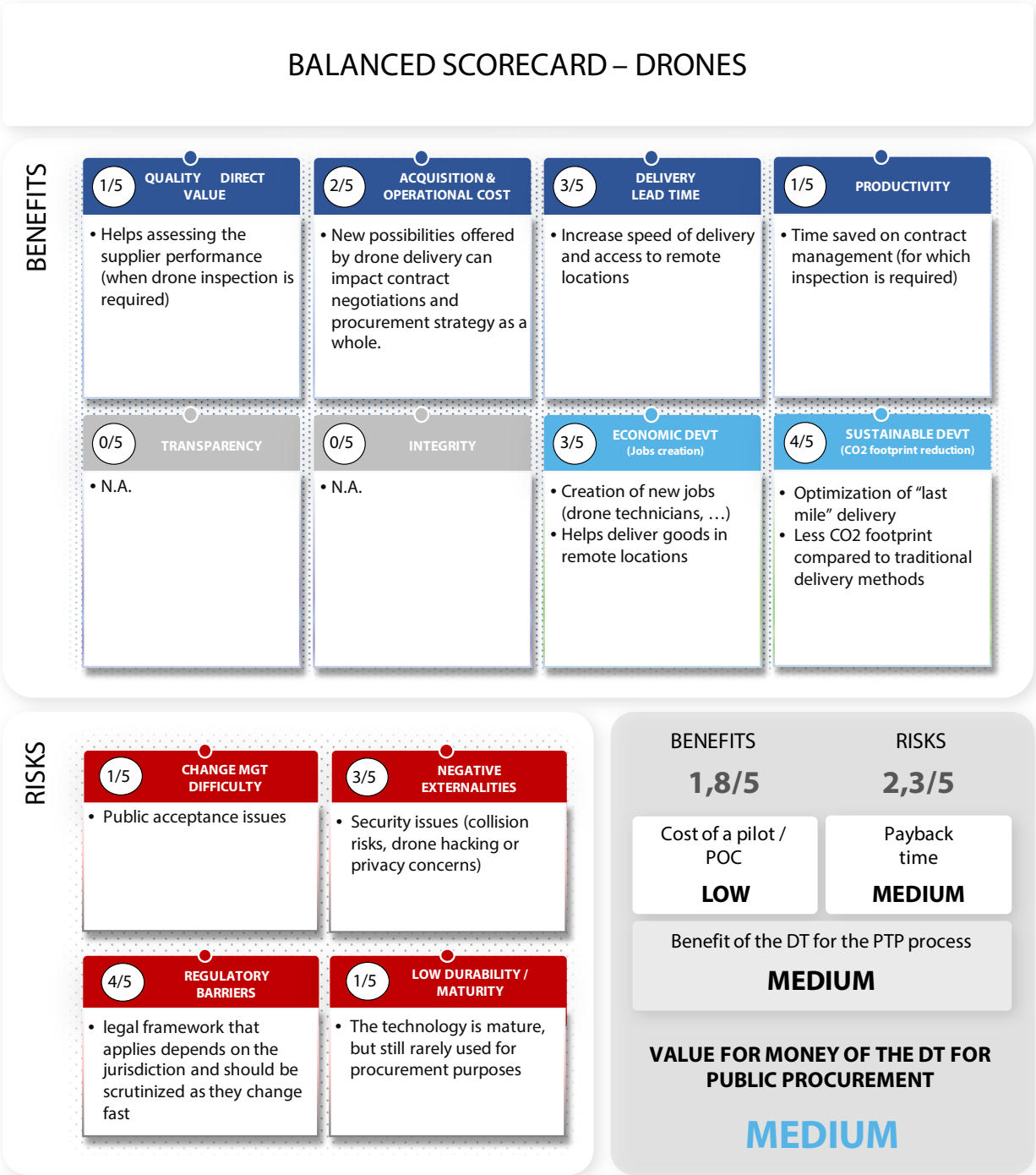
6. **Prerequisites**

- Although the infrastructure needs related to UAS application are limited, using it on a regular basis requires charging stations, landing facilities, and other assets.
- Drones also require trained personnel, especially as their sophistication is constantly improving. Security protocols have to be introduced to ensure they will be used only for professional purposes.
- In addition, obtaining data from drones is only the first step. The data must then be processed in order to extract useful information for the various clients, which raises new challenges with regard to current solutions. The competitive field is moving increasingly toward turnkey solutions that combine the UAS and all the software that make it possible to take advantage of the collected data.

7. **Balanced scorecard**

- See Figure 25.

Figure 25. STC Balanced Scorecard – Drones (UAS)



Use cases

- Ghanaian Health Service using drones for vaccines delivery

Prerequisites

- Drone related infrastructure (launching pad, hangar, …)
- Skilled workforce (technicians, …)

Related technologies & software

- 3D Printing

3D PRINTING

The benefits of introducing 3D printing (or additive manufacturing) into the public procurement sector have recently been demonstrated by the COVID-19 crisis, during which some countries have suffered from fragile supply chains while essential medical products were urgently needed.

3D printing does not directly affect the public procurement process, but it has to be considered by buyers, in particular when defining procurement and sourcing strategies.

1. **Direct benefits**

Additive manufacturing as an interesting option in the decision to "make or buy"

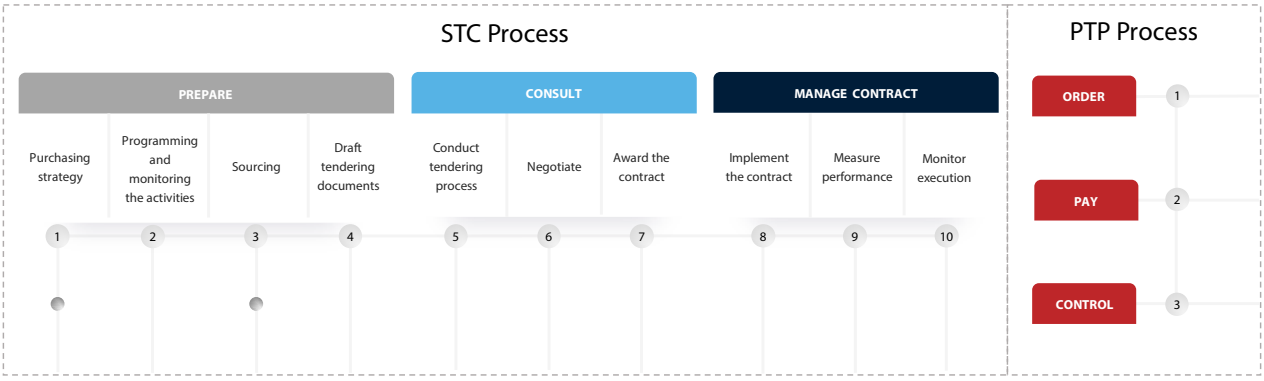
- In some cases, suppliers are no longer interested in old, long-term infrastructure because the know-how got lost or suppliers switched their efforts to higher margin products. Many contracting authorities face difficulties in obtaining essential spare parts. **In cases of obsolescence**, it may be interesting to consider the option of additive manufacturing as a reliable "purchasing lever."
- Indeed, 3D printing is an attractive way to stock up on numerous spare parts and is especially interesting for rarely **requested parts that are needed in small batch sizes.** An example is the spare parts of vehicles that have long been withdrawn from series production.
- In addition, **additive printing can be extremely advantageous because it can reduce delivery risks.** It may in fact eliminate the delivery cycle of those items that are both low value and critical; since the product is available as soon as it is manufactured, there are no (or limited) costs associated with customs or transportation. This switch to a local or internal capacity is even more valuable when the contracting authority is isolated or located far from industrial zones or logistical hubs. The more distance that is avoided through additive manufacturing, the more the risks of waiting time are removed.

Cost savings

- 3D printing is also a way to cut costs in comparison to standard manufacturing. 3D printing production costs per unit are generally much higher than traditional manufacturing. However, this is not always true in the case of items being phased out of production series, **and it does not require minimum order quantities.** In those cases, public organizations can directly produce the quantity of the product they actually need, which also allows them to save significant warehousing costs. 3D printing can bring **financial gains in four additional ways:**
  - Reduces transportation and customs costs
  - Extends the lifetime of machines and reduces possible downtime, which in total reduces the TCO
  - Cuts costs associated with the storage

Figure 26. STC-Impacted Steps - 3D Printing

Steps of the procurement process potentially impacted through 3D printing



and transportation of spare parts

- Increases an organization's bargaining power with traditional resellers on the more critical items
- **Enables procurement personnel to avoid time-consuming sourcing or negotiation processes** as it offers an alternative to buy low value but rare products, **allowing them to focus on higher value-added activities**

Useful in the case of shortages

- The recent crisis in stocks of protective equipment sparked by COVID-19 has revealed that 3D printing can bring substantial benefits in terms of security of supply. When the traditional supply chain is under strain, some local or national initiatives, based on public-private partnerships, can introduce alternatives, as **demonstrated in the case of Northwell Health** (see chapter VI, case #18). Nasal swabs purchased by U.S. health care providers are typically manufactured in Italy and China, countries whose supply chain was disrupted because they were centers of the initial COVID-19 outbreak. In an effort to relieve the bottleneck for coronavirus testing in the United States, a consortium developed that manufactured 3D printed nasopharyngeal test swabs.

2. **Complementary benefits of 3D printing (shipment, invoice processing, spend management, etc.)**

- The benefits of 3D printing to the public procurement sector have been demonstrated by the pandemic, when 3D printing helped hospitals in some countries overcome the scarcity of some critical products (see below).

3. **Compliance and positive externalities**

- In some isolated areas, the introduction of additive manufacturing could lead to the development of an ecosystem of local manufacturers and buyers that could share technology, skills, and model files to bypass traditional supply-chain issues.
- The introduction of additive printing also offers the benefits of eliminating the CO_2 emissions involved in normal delivery methods, which often require long distance travel. Moreover, 3D printing allows the production quantities to be matched to the requirements, thus reducing the amount of waste generated.

4. **Risks: change management difficulties, regulatory barriers, and negative externalities**

- Risks associated with the development of additive manufacturing as an alternative to buying items in a traditional way are of two types:
  - The organization must implement a real strategy to train its staff in the use of these tools, and the acquisition of the required skills is far from easy, particularly in remote areas where 3D printing is to bring the more value added. The use of 3D printing without clear protocols and comprehensive training programs can lead to quality defects, which can create major problems when it comes to manufacturing critical items.
  - 3D printing programs will also need to ensure respect for the legal aspects related to the intellectual property of 3D model files. These plans are generally protected by the same rights as original products in commercial trade, but for some products the use restrictions are lifted after several years. These property right issues must be addressed on a case-by-case basis, as regulations mostly depend on national frameworks.

5. **Mitigation measures**

- Mitigation measures are outlined in chapter V, where a number of good practices are presented to address the following risks:
  - Procurement complexity and difficulty in specifying

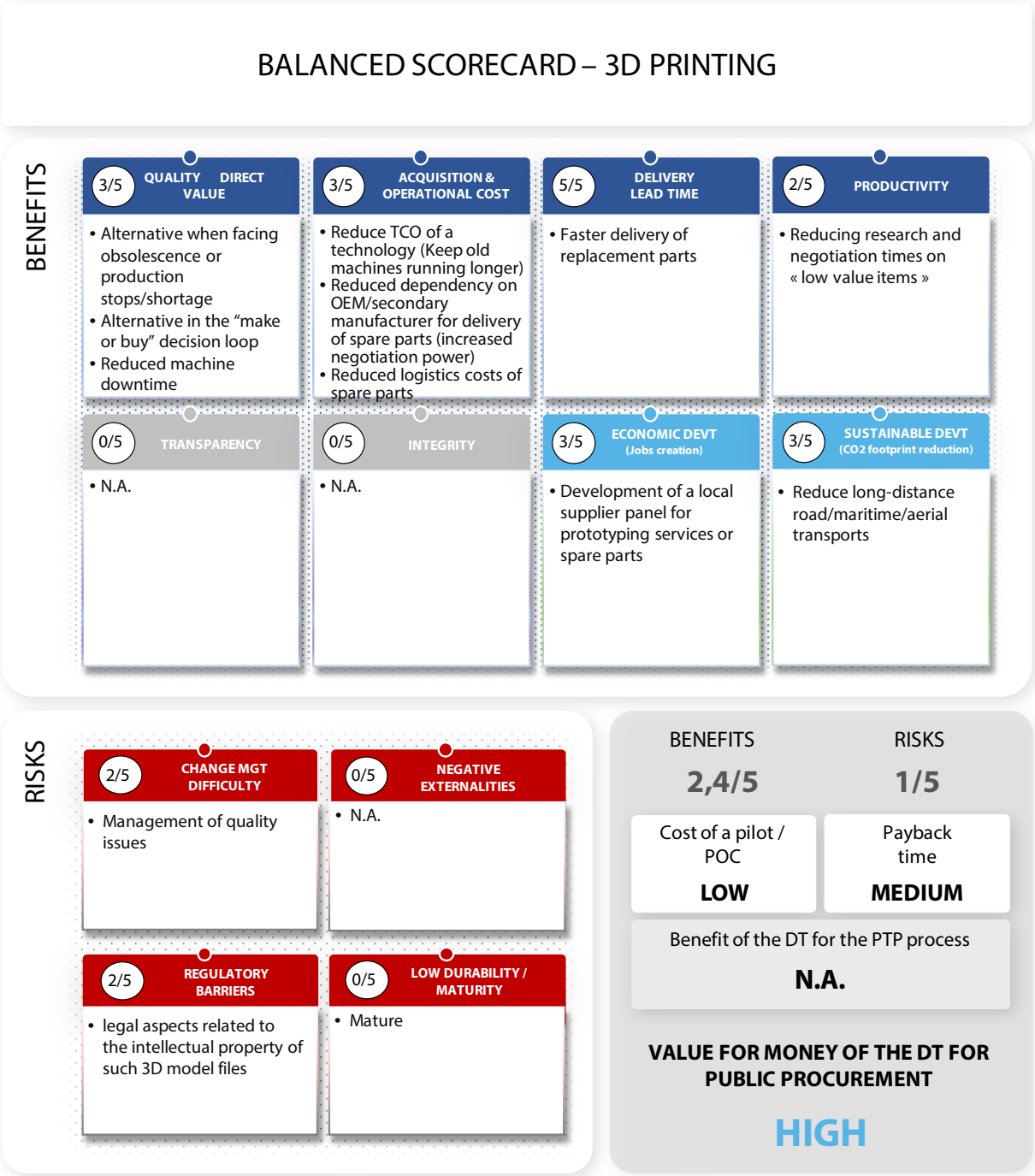
6. **Prerequisites**

- In addition to the training needs already mentioned, the installation of equipment may require a small investment.

7. **Balanced scorecard**

- See Figure 27.

Figure 27. STC Balanced Scorecard - 3D Printing



Use cases

- The Beth Israel Deaconess Medical Center (USA) manufacturing nasal swabs with 3D-printers.
- Self-manufacturing of ventilators at the Parc Tauli Hospital (Spain)

Prerequisites

- Emphasis must be put on personnel training to avoid quality issues

Related technologies & software

V. GUIDANCE ON ASSESSING AND IMPLEMENTING THE FIT-FOR-PURPOSE DISRUPTIVE TECHNOLOGY

MAIN DRIVING FORCES IN ADOPTION PER DT AND TYPE OF COUNTRY

The main forces identified that influence the adoption of the DTs outlined above are:

- Estimated time to technology maturity (speed at which technology is improving)
- Importance of value created for public procurement (expected benefits)
- Capacity of fast ROI generation (payback time)
- Availability and capacity of the infrastructure to support the use of the DT
- Ability of the legacy systems to provide a "backbone" and relevant data to the DT
- Political will, that is, to what extent the diffusion of the technology can be driven or hindered by political or social agendas
- Ease of enacting legislative amendments (regulatory framework)
- Appetite or openness to new technology, skills, and knowledge-sharing capacities (human capital development)
- Financing model (public, private, blended financing) and possibility of mutualization with other projects

See Figure 28 for Diagram of the adoption forces.

Figure 28. Diagram of the Adoption Forces

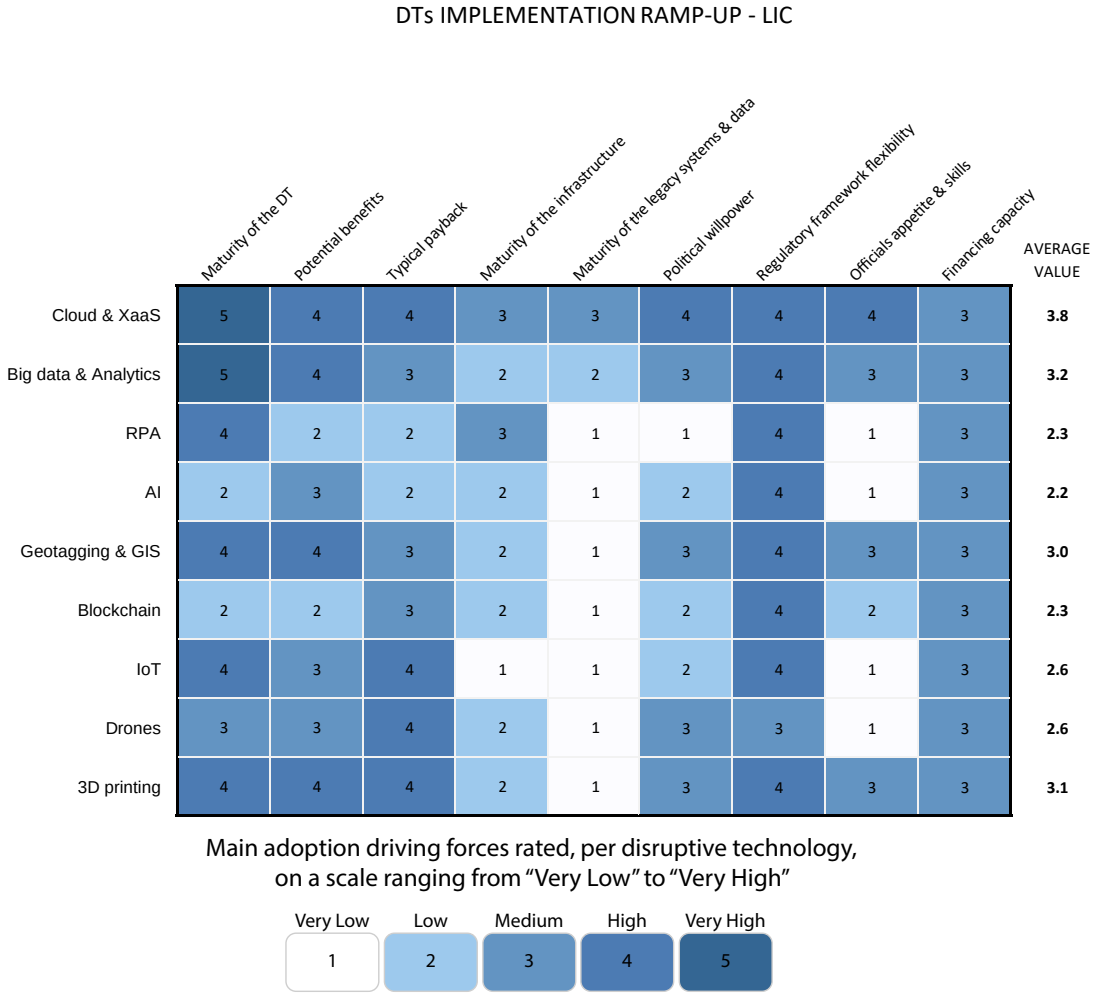
The importance of these forces has been measured for each technology and a scoring established on a scale of 1 to 5, with 5 the highest score.

DRIVING FORCES IN THE ADOPTION OF DT IN FCV COUNTRIES AND LICS

In FCV countries and LICs, endogenous drivers, such as the maturity of the legacy systems, maturity of the infrastructure, or the development of human capital, have a strong influence on the most effective strategy for DT implementation.

Paradoxically, the ease of action of the regulatory framework is always an asset. In FCV countries and LICs, the impacts on the regulatory framework and derived public procurement procedures, which are related to the implementation of new technologies, may be easier to grasp. The less mature technologies, that is, those that are the

Figure 29. Driving Forces - LICs and FCV Countries



most human capital-intensive and have the most uncertainties in terms of ROI, will be implemented over the long term.

Conversely, the most mature technologies (in purely technical terms but also in terms of the supplier market), if they are accessible (i.e., reduced acquisition costs and skills requirements) and produce benefits quickly, are more likely to be used in the relative near term. This is typically true for cloud and XaaS technologies (SaaS, STC, and PTP platforms).

In a mid-term perspective, big data and analytics, 3D printing, and geotagging and GIS are candidate technologies for implementation. Except for specific and targeted application (e.g., delivery of medical supplies by drones), it would be prudent to wait before investing in the other technologies for broad use.

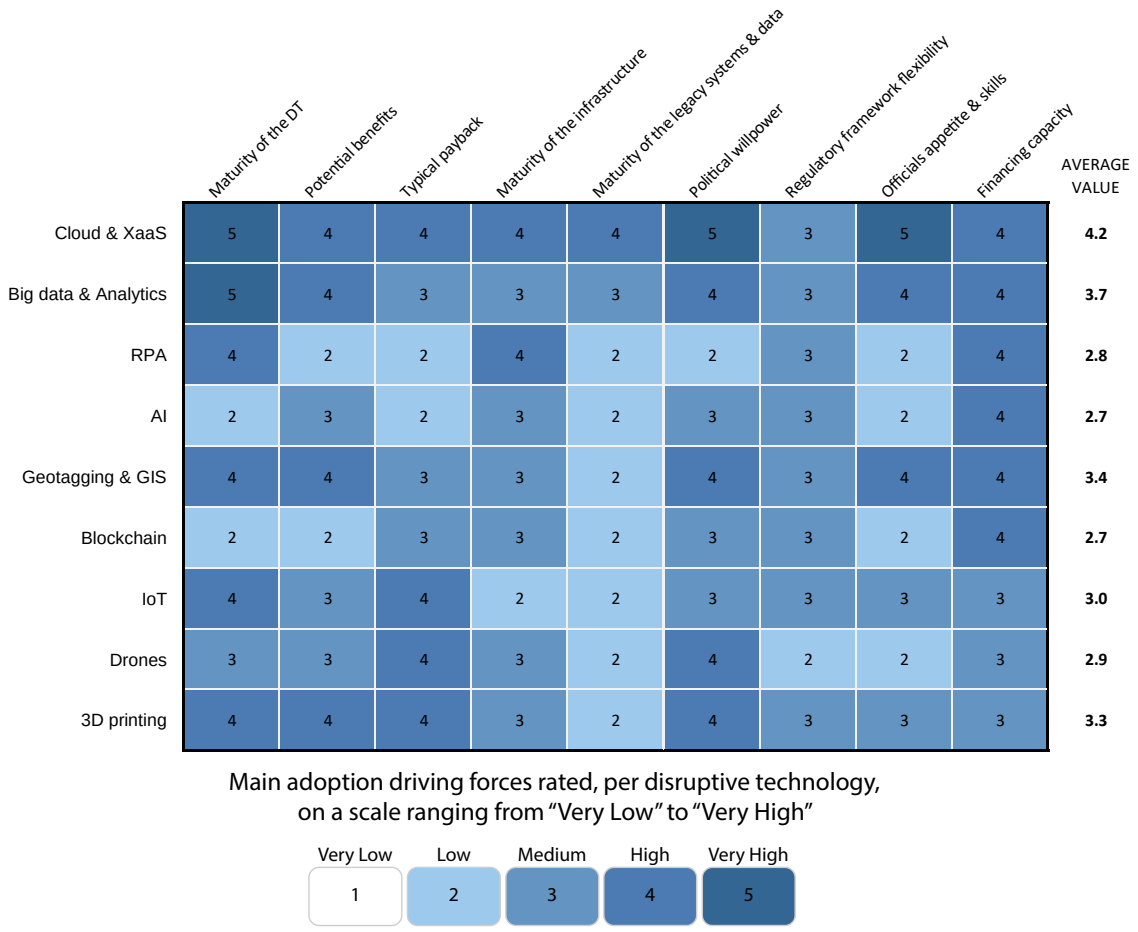
DRIVING FORCES IN THE ADOPTION OF DT IN MICS

In MICs, the maturity of the legacy systems, maturity of the infrastructure, and human capital development (the willingness of procurement officials to adopt new IT skills and the availability of those skills) are sufficiently important to allow an immediate step toward the adoption of cloud and XaaS and big data and analytics technologies.

The development of the use of geotagging and GIS and 3D printing are considered to be in the second stage, though very close to the first.

An opportunistic approach can be used to

Figure 30. Driving Forces - MICs



obtain quick and tangible results using other technologies on specific and targeted applications (e.g., the IoT to help monitor the execution of public contracts).

DRIVING FORCES IN THE ADOPTION OF DT IN HICS

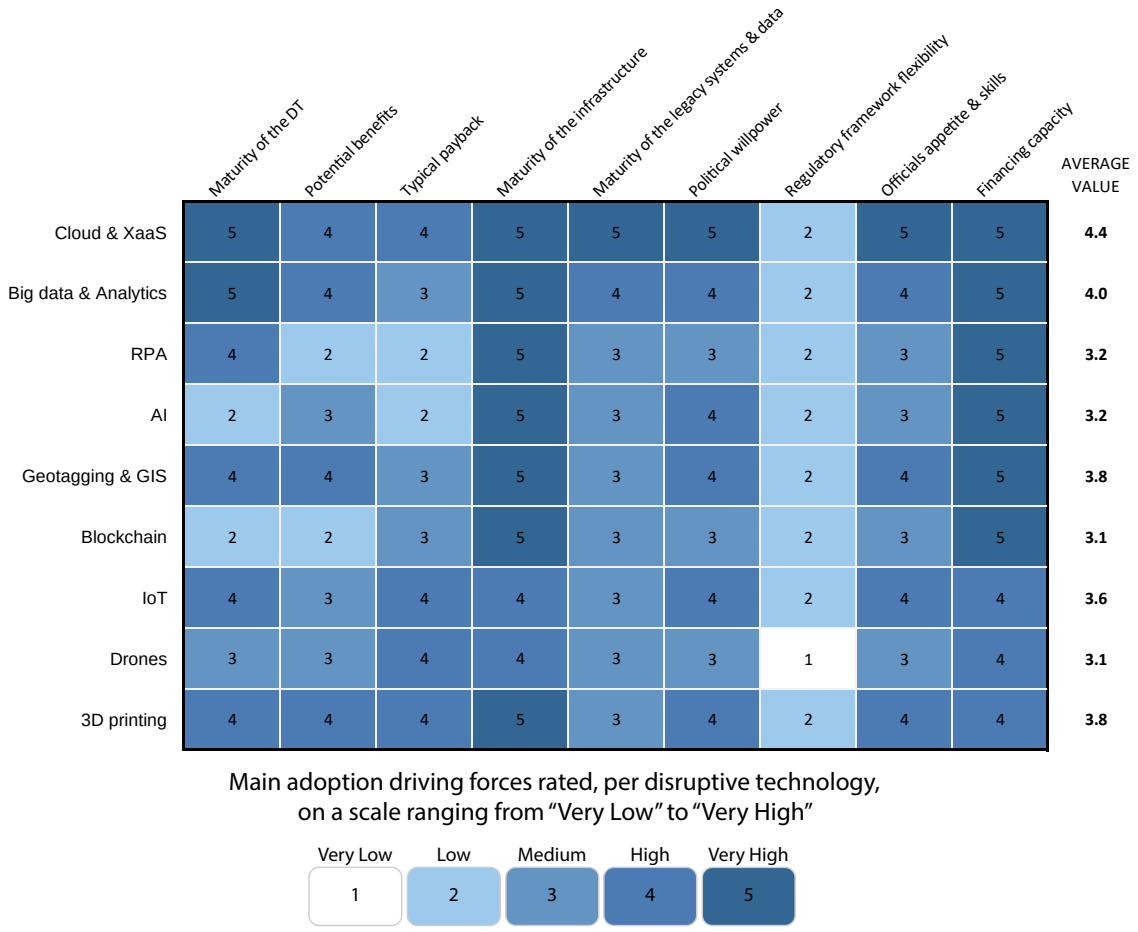
In HICs, some DTs have already been deployed on a large scale, while others are still in the experimentation stage to assess the positive and negative impacts of their use in public procurement.

In addition to financing innovation and questioning existing information systems, the main limits to the widespread adoption of DTs are the regulatory obstacles. It is not just public procurement laws that are being impacted by the advent of DTs, as data protection regulations also have to be reexamined in light of the use of big data and analytics, geotagging and GIS, or IoT technologies. Regulations attached to intellectual, industrial, and commercial property have to be considered when using 3D printing. Air transportation regulation is similarly impacted by the rise in the use of civil drones.

In a profession where there is an understandable aversion to legal risk and where change management is often quite cumbersome, these regulatory obstacles can be removed only if there is strong political will to do so.

DTS' MATURITY CURVE AND SPEED OF ADOPTION IN

Figure 31. Driving Forces - HICs



PUBLIC PROCUREMENT

Figure 32 presents the **maturity curve of technologies in the area of public procurement.**

More specifically, the graph first indicates the phase of the development cycle in which DT applications in public procurement currently are **(development, introduction, growth, maturity plateau, decay)**. It then presents the estimated time needed for the technology to reach the maturity plateau **(time to maturity)**. Finally, the graph indicates the adoption speed resulting from the force analysis **(speed of adoption/ diffusion)** for each technology.

POTENTIAL "RAMP-UP" PER DT, USAGE, AND TYPE OF COUNTRY

One conclusion of this analysis is that the relevant order of technology adoption does not differ significantly depending on the type of country. The Figure 33 shows that cloud and XaaS is the easiest technology to appropriate in every case. It also suggests that an early introduction of blockchain-based technologies is interesting even if the countries are less wealthy.

This modeling exercise clearly identifies potential rapidly diffusing technologies that may not have been considered at first glance.

Ramp-up modeling for LICs

When looking more precisely at the ramp-up model in FCV countries and LICs, it appears that by far, cloud and XaaS is the technology that should be adopted first (see figure below). However, for these countries, the environment is still not mature enough to allow for the fast and

Figure 32. Maturity Curve

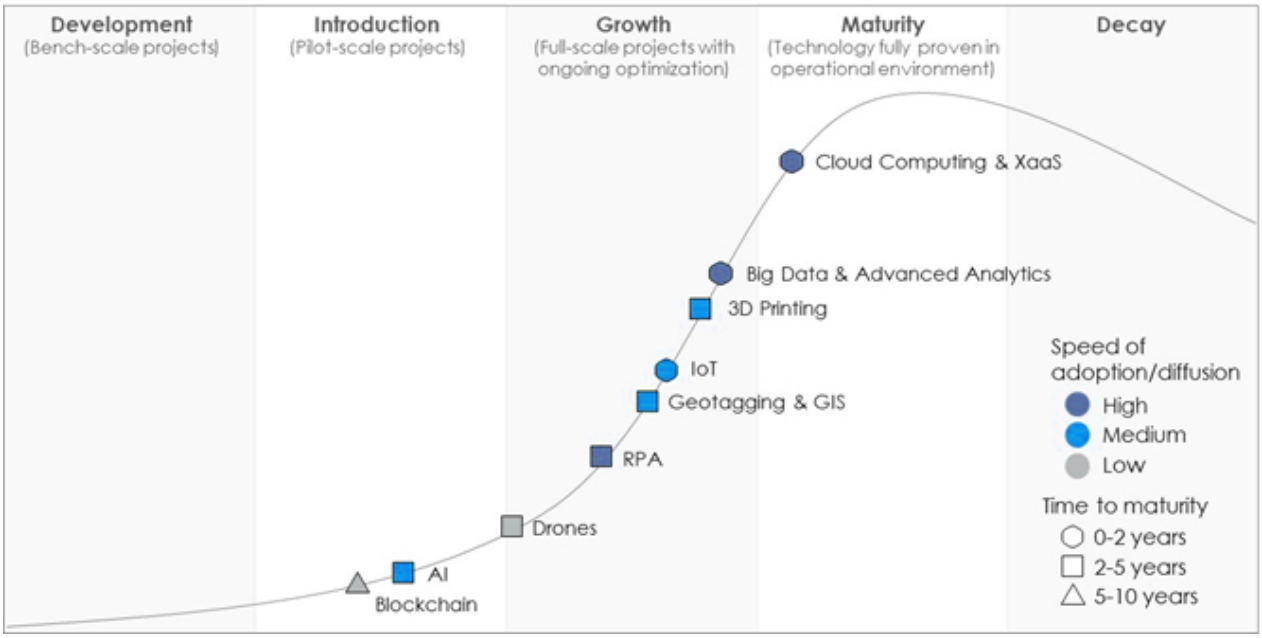
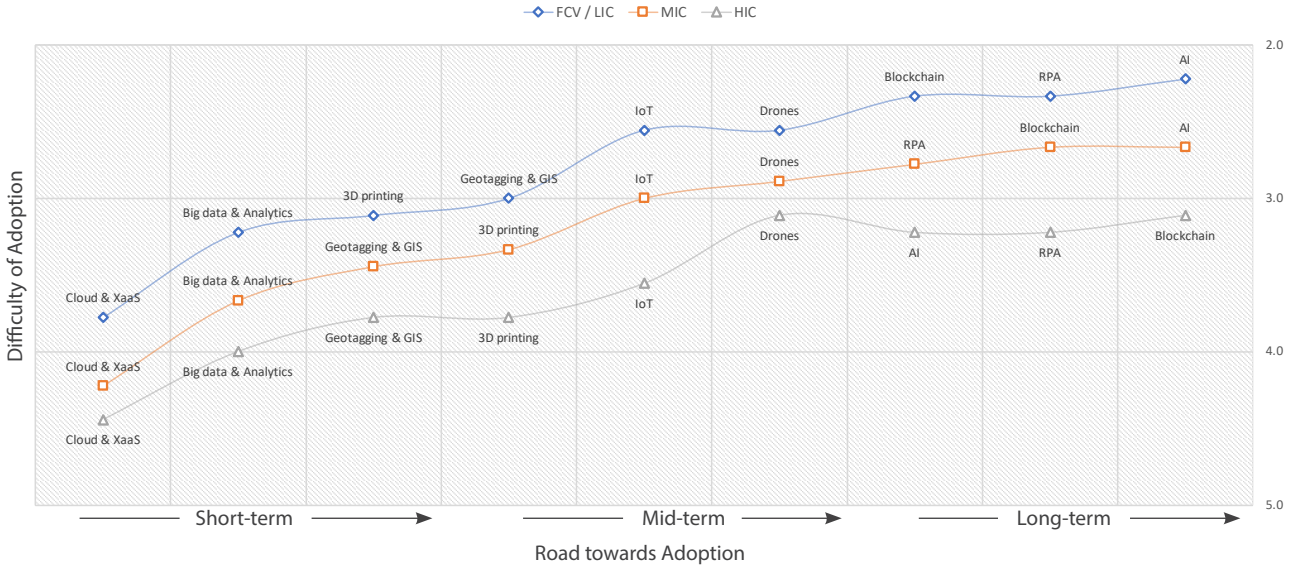


Figure 33. Potential Ramp-Up by Type of Country



successful introduction of RPA, blockchain, and AI technologies in public procurement.

Ramp-up modeling for MICs

For MICs, the adoption of big data and analytics seems to make sense at an early stage and could be coupled with the introduction of cloud computing technologies. As in LICs, IoT tools and drones are categorized approximately the same way and could be reasonably integrated on a mid-term horizon.

Ramp-up modeling for HICs

In HICs, the technological and economic environment seem to enable a short- to medium-term adoption of any of the DTs described here. Surprisingly, drones appear to be the least suitable technology for early adoption.

Mixing DTs

It may be useful to adopt a combination of DTs to leverage their respective potential and

Figure 34. Ramp-Up Modeling - LICs and FCV Countries

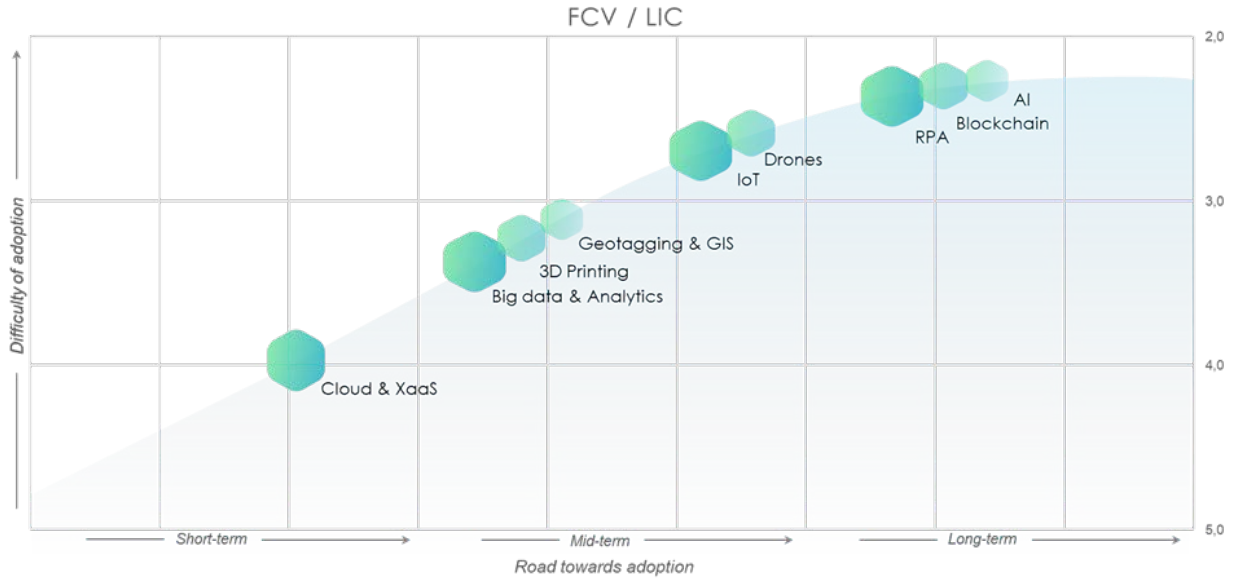
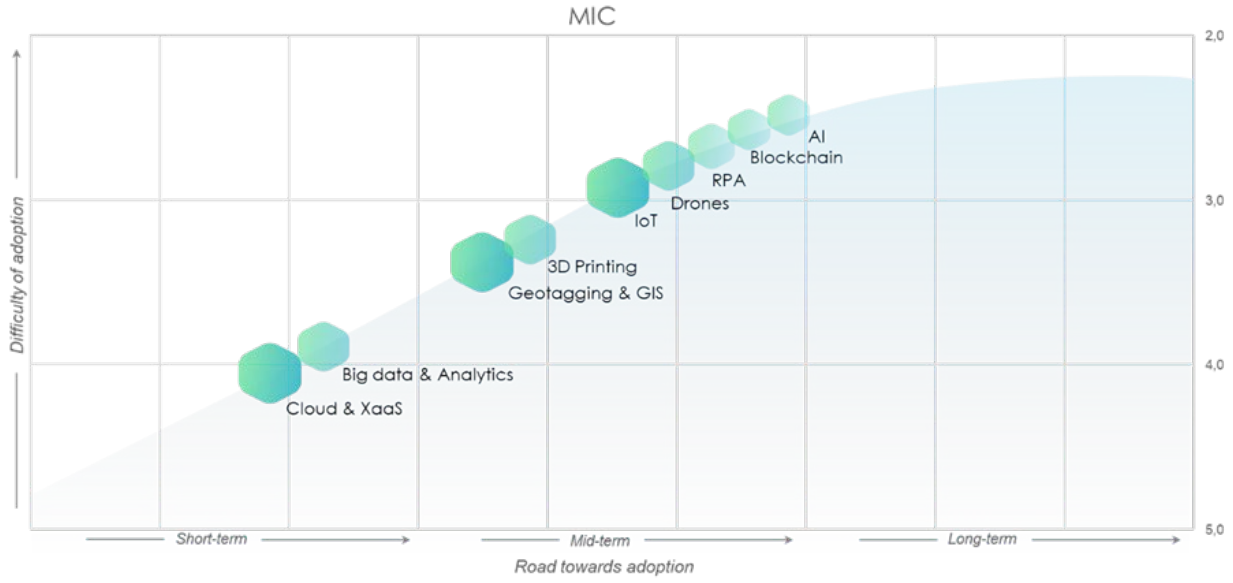


Figure 35. Ramp-Up Modeling - MICs



create additional value. The level of interaction between DTs rated on a scale ranging from very low to very high is presented in Figure 37.

When public authorities are considering an investment in DTs, they should explore the opportunity to combine technologies in order to take full advantage of the potential for value creation.

Typically, the benefits of SaaS platforms will be significantly boosted by big data and analytics, as these platforms produce accurate and reliable data that can be consolidated and turned into high value-added analytics.

Similarly, as AI requires a large amount of data to produce relevant results, big data is very often associated, as a backdrop, with AI.

In the same vein, GIS will have to rely on big data and analytics to offer insights that go far deeper than what traditional business intelligence systems are able to do. Depending

Figure 36. Ramp-Up Modeling - HICs

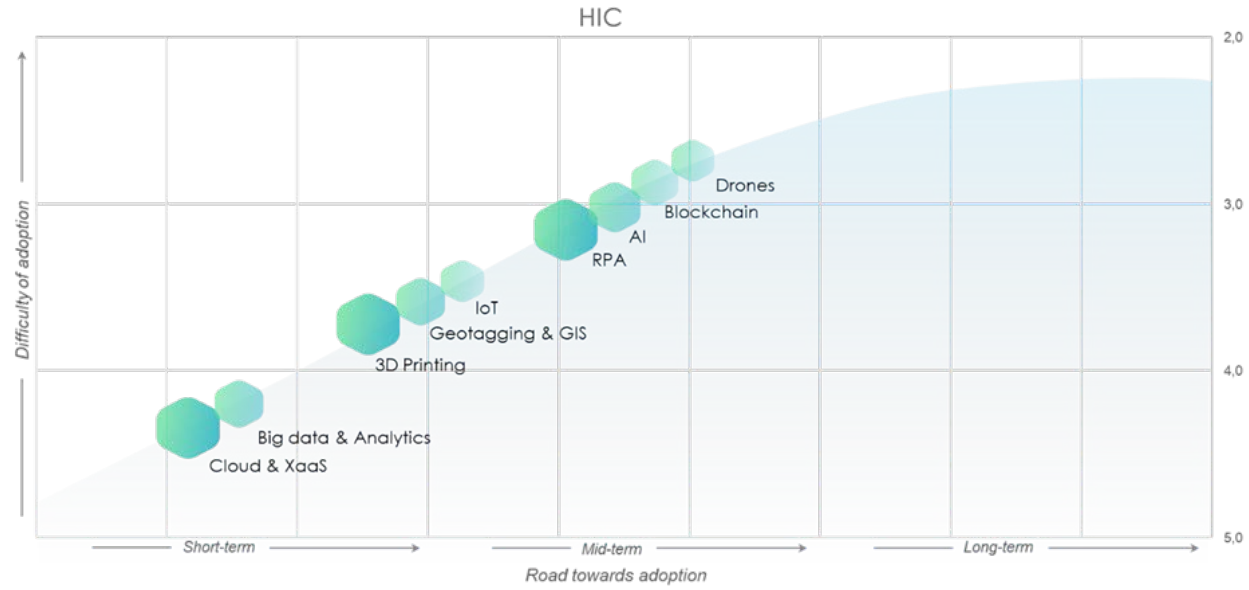
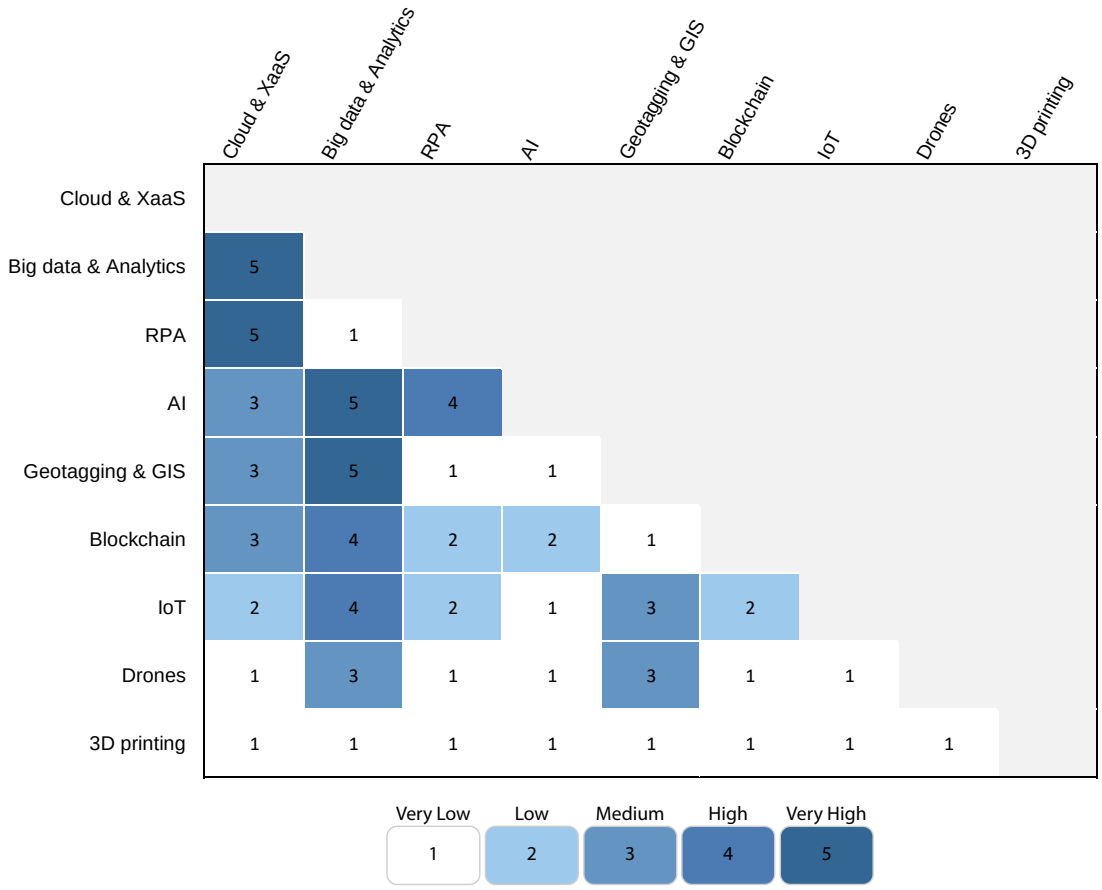


Figure 37. Combination of DTs

LEVEL OF INTERACTION / POTENTIAL SYNERGIES BETWEEN DTs IN PUBLIC PROCUREMENT



on the application, DTs may be dependent on each other. For example, the IoT and GIS are frequently associated to steer the execution of contracts relating to the management of water, energy, transport, or waste infrastructures.

LEGAL CHALLENGES FOR EACH DT

LEGAL, TECHNICAL, AND MANAGEMENT FRAMEWORKS

To thrive, DTs have to overcome a variety of barriers, such as concerns about data protection and privacy, security, compatibility/ interoperability, reversibility, and others.

Figure 38. Legal, Technical, and Management Frameworks

To prevent a lack of fairness in public procurement and the potential misuse of DTs, legislative and regulatory frameworks are necessary to address the ethical issues involved. Typically, these can include how to secure equity of access to public contracts, how to guarantee a balanced and fair relationship between the contract parties, how to protect the vendors' intellectual, industrial, and commercial property, and so forth.

Regulation aims to ensure a coherent framework, with a view to offering contracting authorities a high level of security and legal certainty when using DTs.

An extensive regulatory framework is not consistent with a cost-efficient approach to public procurement, as official concerns about eliminating risk cannot be eased by strictly complying with the framework. The integration of new means/technologies into highly regulated environments will imply the heavy reengineering of the procedures involved. Micro-regulation of the process can also undermine the responsibilities of procurement officials, which can in turn hinder accountability, except in terms of compliance.[13]

It is important that regulatory and technological standards do not hinder or slow the adoption of DTs. Governance should not just address the imbalances in the market but also foster the development and adoption of new technologies as major vehicles for economic growth, citizen satisfaction, and transparency in the public contracting.

Typically, as data is the "fuel" for many DTs, data management strategies must be defined by countries or by integrated economic areas.

The collection of reliable and harmonized procurement data is largely understood as a means to developing insight into the performance, transparency, and integrity of public procurement. The more that procurement data are merged with other sources, the more that intelligence and value can be expected from the analytics. Typically, governments are most interested in assessing the impact of public procurement on public finances, economic growth, or the success of public policies, including the quality of public services, development of innovative SMEs, reduction of the environmental footprint, access to work for people with disabilities, and so on. Many countries make procurement data publicly available to facilitate a kind of "civic auditing" and hold contracting authorities accountable for the efficient use of public resources. However, the use of the data raises important ethical and technical issues, and regulations should establish requirements for data protection.

Data management strategies and regulations will administer data use, including by determining the standard formats for the data; how to capture, store, and protect it; its location and who can

[13] P.R. Schapper, N. V. Malta, and D. L. Gilbert, "An Analytical Framework for the Management and Reform of Public Procurement," Journal of Public Procurement 6, nos. 1 and 3 (2006): 1–26.

access it; how it may be monetized; and so forth. These strategies and regulations are usually part of broader considerations on open data management.

Regulation should, as far as possible, be technology neutral (e.g., blockchain regulation should be cryptocurrency agnostic). It should ensure the preservation of public procurement information over extended periods of time, irrespective of future technological changes. It should also ensure the maximal interoperability of the technologies chosen.

In a context of immature technologies and fast-moving markets, this is an ongoing challenge. Regulations should clarify the liability of all stakeholders (public bodies, providers, economic operators, etc.) in the case of failure to comply with obligations. Available financing or budget may be a constraint to the implementation of disruptive innovation, and regulations should also allow for DT financing through public-private partnerships.

To facilitate the exchange of data and interoperability between devices and/or systems, governments may also impose protocols by law. Typically, many countries rely on international open standards to set out these protocols. The International Standards Organization (ISO) is responsible for coordinating these efforts. In the meantime, alliances are forming to unify the fractured DT landscapes and push protocols at the different DT layers (e.g., Sigfox, LoRa in the IoT industry). A trade-off between open and proprietary protocols is definitely a key challenge.

Governments will also bring forward management frameworks in the form of procedures and policies to ensure the fair use of DTs. Many guidelines, codes of ethics, codes of conduct, and codes of practice have been issued to strengthen the governance of public procurement and mitigate risk, such as the "Technology Code of Practice of the UK Government"[14] or the "Code of Conduct for Procurement Practitioners"[15] of the Organisation for Economic Co-operation and Development (OECD).

TYPICAL IMPACT OF DTS ON THE REGULATORY FRAMEWORK OF PUBLIC PROCUREMENT

To thrive, DTs have to overcome a variety of barriers, such as concerns about data protection and privacy, security, compatibility/interoperability, reversibility, and others.

The legal risk and impact of DTs that are applied to public procurement are of varying magnitude and cover the different regulatory fields.

Virtually all DTs, since they make data the engine of value creation, raise essential questions regarding data protection. Legislation on the security of personal data, confidential business information, and intellectual property must be reexamined in view of the development of the new use scenarios permitted by DTs.

Public procurement laws must also be revisited. Typically, the protocols and technical requirements attached to public procurement, sometimes imposed by legislation, must incorporate the possibility of employing DTs (e.g., blockchain). First and foremost, the integrity of procedures must be guaranteed and the interoperability of systems and their ability to communicate must be considered, in particular to allow cross-border purchasing. It is worth noting that recently, many governments have adapted existing legislation to address the new habits and business procedures allowed by these technologies. The European legal framework was designed and adopted in 2000 to give legal value to the digital signature and to

[14] United Kingdom, Government of, "Technology Code of Practice," 2019, https://www.gov.uk/government/publications/technology-code-of-practice/technology-code-of-practice.

[15] OECD, "Tool: Code of Conduct for Procurement Practitioners," OECD Procurement Toolbox, http://www.oecd.org/governance/procurement/toolbox/search/code-of-conduct-procurement-practitioners.pdf.

define the terms of its use.[16] Other technological innovations have more recently led to regulation changes in many countries, such as the legal frameworks governing civil aviation following the widespread use of drones or the laws on data privacy issues.

Liability policies must be also adapted to new modes of communication and information management. DTs are "reshuffling the cards" in terms of stakeholder roles and responsibilities, including those of potential new intermediaries (e.g., cloud computing and XaaS).

Since the law is a malleable subject, feedback and jurisprudence from the first applications of DTs to public procurement can inform the work of regulatory reform. The risks and regulatory stakes generated by the use of DTs in public procurement can be schematized as shown in Figure 39.

1. PROTECTION OF PERSONAL DATA

The challenge is obviously to guarantee the protection of the persons concerned in processing their personal data and to increase the responsibility of the stakeholders involved in this process. The strength of some DTs can also be their weakness.

Typically, the blockchain offers the benefit of "distributing" the information processing, thus increasing the degree of confidence that the various stakeholders have in public organizations (including citizens). The data are securely entered in the blockchain, thereby limiting fraud, falsification, and other misuse. Blockchain is a highly reliable, shared, confidential, and nonrefutable transaction system (providing automatic and transparent reporting).

Important questions arise, particularly because blockchain eliminates the traditional trusted third parties (i.e., governments and certified electronic signature providers) and because the security and scalability of BCTs are not yet fully tested.

Data are essential to the blockchain and much of it is "personal" data (private keys for encrypting messages, names, email, etc.). Several studies, including a study by the EU Blockchain Observatory and Forum, suggest that this technology is incompatible with the rules of the GDPR.[17]

The GDPR gives individuals the right to request the deletion or rectification of their data. However, the blockchain is built around the principle of immutability of the data engraved

Figure 39. Overview of Legal Issues

[16] EC, "eSignature Documentation," What is the Legislation?, https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/What+is+the+legislation+-+esignature.

[17] EU Blockchain, "Blockchain and the GDPR" (Brussels: European Commission, 2018), https://www.eublockchainforum.eu/sites/default/files/reports/20181016_report_gdpr.pdf.

within its blocks. Without this, the absence of fraud would no longer be guaranteed, and this technology would lose its value. This seems to be the same for data that must be purged when processing is no longer necessary (e.g., at the end of a contract).

The use of blockchain in public procurement calls for a reflection on the type of blockchain platform to be implemented. Strategic choices must be made, in particular regarding the implementation of public, private, or permissioned blockchains. The first offers strong guarantees of decentralization and the transparency of information processing but comes up against many legal issues, while the private and commissioned approaches are more difficult to deploy at the country or area level and may be less transparent. The authority that owns the control layer can restrict access, but the identity of the peers is known and less secure. The integrity of the network can be compromised but still offer a better performance (a limited number of nodes) and be more easily compatible with the regulations in force. Among the drawbacks of private or permissioned blockchains are that these approaches give public bodies the opportunity to build, at great expense, "tailor-made" solutions whose durability and interoperability will be limited.

2. PROTECTION OF INTELLECTUAL, INDUSTRIAL, AND COMMERCIAL PROPERTY

Intellectual property issues surrounding the use of DTs may be very important. Typically, the protection of intellectual property rights (copyright, trademarks, design, and patents) can be at the heart of the uses of 3D printing.

Digitization of an object with a 3D scanner and then the object's reproduction with a 3D printer may constitute intellectual property infringement. Since 3D printing is still a relatively uncommon technology in public procurement, intellectual property problems are currently limited but are likely to increase. At this stage, however, it may be prudent not to penalize innovation by acting at the legislative level, not least because the COVID-19 crisis has highlighted the use of 3D printers by public authorities to compensate for market deficiencies and to meet public service continuity needs.

Patent, design, and copyright laws will need to be reviewed when there is sufficient feedback. When the time comes, the creation of a sui generis right for 3D printing could be considered in order to meet the new challenges. The use of 3D printing also raises other legal issues, including product liability and data protection.

3. PROTECTION OF CONFIDENTIAL BUSINESS INFORMATION

Confidential business information is data about an economic organization that should not be public. If this information is disclosed, it may cause substantial harm to the competitive position of the organization. Confidential business information covers a wide array of subjects, such as price policies, trade secrets, processes, operations, source of income, profit, expenditures, and so on.

The increased possibility of the triangulation of numerous data sources, as well as the development of cloud computing and XaaS and big data and analytics applications, in particular to manage supplier risks but also to optimize purchasing strategies by sharing public contract results, clearly raises the need for a regulatory framework that ensures the protection of confidential commercial data.

4. PROTECTION OF THE FUNDAMENTAL PRINCIPLES GOVERNING PUBLIC PROCUREMENT

The introduction of new technologies must not undermine the fundamental rules and principles governing public procurement. Typically, DTs must not call into question the principles of free access, equal treatment, and the transparency of public purchasing.

The pursuit of economic gains through the use of a DT must not restrict the access to public procurement markets of economic operators who do not have the technology at their disposal. Nor should the technological standards adopted by public authorities lead to the ousting of companies facing interoperability problems. In a context where many public procurement platforms are migrating to the cloud, these precautions make sense.

The natural and regular renewal of public procurement contracts cannot be interrupted by technical or financial constraints resulting from investments made in different DTs. Typically, the choice of most of the DTs must be made considering the risks of technical dependency (e.g., consumables for 3D printing) and the issues of reversibility (e.g., cloud computing and XaaS).

A public entity must not disrupt the equal treatment of candidates because it imposes a technology that naturally leads to an imbalance in their level of information and knowledge. Technology choices should be as neutral as possible and not be restricted to the market's ability to meet the functional need. The cost of changing suppliers that are awarded contracts must be borne by the public entity and not by the new entrants.

Whatever the stage of the purchasing process, the traceability of the actions carried out and the transparency of the choices made must be ensured or even reinforced. Most DTs significantly increase the transparency of public procurement, which may also be an obstacle to their adoption. Public employees and public organization leaders are not always concerned about creating such transparency. It is therefore essential that the benefits attached to DTs are well understood by those who use them and that these benefits are perceived as outweighing any threats.

The acquisition of DTs must be made on the basis of TCO or even total value of ownership (TVO) models, making it possible to assess all the costs (internal and external) and the soft or hard benefits (possibly revenues) over the life cycle of the technology. The proper use of public resources remains an inescapable requirement.

KEY SUCCESS FACTORS AND MAIN RISKS TO BE MITIGATED

This section assesses the levels of risk associated with six major issues that generally apply to IT projects. For each technology, the risk levels are presented in the tables on a scale of 1 to 5, with 5 the most significant risk level. They are estimated on the basis of the experience observed on projects to implement the technology, whether for procurement or similar purposes. The criteria used to qualify these risks are detailed in the introduction to each of the subsections below. The colors of the tables are differentiated according to the type of risk. In addition to the risks and prerequisites detailed in this section, it should be remembered that the benefits of most of the technologies studied require a permanent and good quality internet connection. This is particularly the case for cloud computing, big data, and GIS.

For each type of risk that has been identified, key mitigation measures are proposed. These measures are not exhaustive and correspond mainly to control measures, such as those defined by the ISO31000 standard.

Implementation and procurement strategies must be thought out around the following structuring questions:

1. **How to reduce the risks of interoperability between sub-technologies and components of the target system?**

Interoperability means that two systems can understand each other (ability of two or more systems or components to exchange information) and use each other's functionalities. Some technologies need to combine different "subsets" or different components or present an abundance of competing protocols. They are therefore more prone to the risk of interoperability issues (see diagram below). For instance, IoT and GIS are a mix of instrumentations, communication networks, software, and data storage tools. Each of these solutions may provide its own

infrastructure, devices, APIs, and data formats, leading to interoperability issues. Lack of interoperability results in product functionality and stability problems as well as higher operational costs later on.

Figure 40. Interoperability Issues

		Interoperability Issues				
		1	2	3	4	5
1	Xaas					
2	Big Data and Data Analytics					
3	IA / RPA					
4	GIS					
5	Blockchain					
6	IoT					
7	Drones					
8	3D Printing					

- **Good practices in order to mitigate risks**
  - Carry out preliminary studies
    - In order to minimize risks, it is better to start small with pilot projects and invest progressively according to the roll-out plan.
    - It is useful to prioritize needs (cost/benefit ratio). The objective is to balance the real interest of a functionality with its implementation complexity and in particular, the cost of making several systems interoperable.
    - Plan stages of sourcing interviews that allow for a real understanding of market standards upstream of calls for tenders. Due to lack of time, these steps are too often omitted. These phases of interaction with suppliers must be carried out sufficiently in advance of calls for tenders to allow the specifications or the trajectory to evolve.
    - Choose consultation procedures that develop upstream exchanges between public authorities and economic operators, in particular to develop a detailed understanding of the technical, economic, and regulatory issues at stake.
    - It is important to map applications and components, map the data flows between them, and map the technical prerequisites and their compatibility.
    - These studies often make it necessary to benchmark other organizations (those with a sufficient return on experience). The contractual arrangement must then ensure that a "leader" guarantees interoperability between the different elements.
  - For some technologies where there is an abundance of competing protocols (such as the IoT), it is difficult to circumvent this risk. In order to reduce it, public organizations must first monitor efforts to establish standards to ensure interoperability among devices, networks, services, and data formats. However, it may take a long time before the corresponding standards are fully endorsed and accepted, if at all.

2. **How to guarantee reversibility or transferability to another provider and limit the risks of dependence on a supplier?**

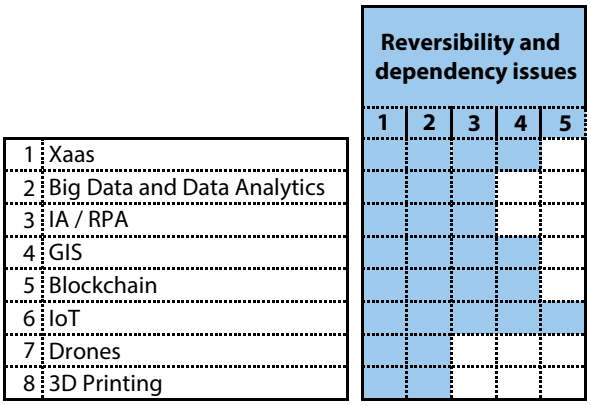
The risk of selecting a solution that quickly becomes obsolete from a performance point of view or too costly to maintain is high for technologies at the beginning of their maturity curve. It then becomes necessary to change supplier and to contract with a new service provider. This transition to a new approach must be thought out in advance, and the contract must be very clear on the supplier's commitments in this area.

This risk usually takes another form on more mature technologies such as SaaS. It is a question of avoiding being too dependent on the editor to make changes in the configuration, for example.

In the table below, levels of risks are assessed

based on various criteria, such as the proportion of development requests met after the project has been set up, the diversity and number of existing suppliers, the level of competence required for the technology's appropriation, and so on.

Figure 41. Reversibility and Dependency Issues

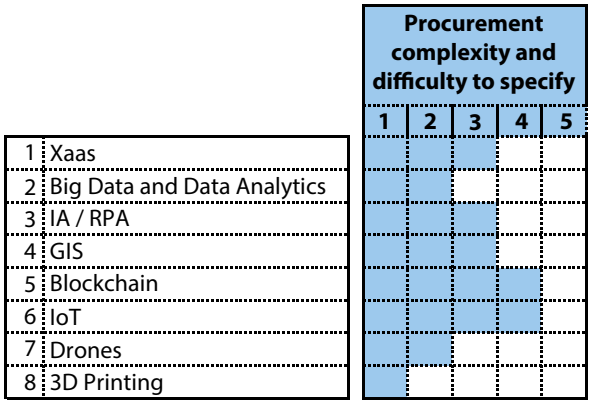


- **Good practices in order to mitigate risks**
  - Formalize very clear commitments in the tendering documentation in the event of reversibility/transferability, in particular with regard to the migration of historical data to the new system. The quality and format in which the data must be returned (in order to migrate it into the new system) must be precisely defined. In the same way, very precise commitments in terms of documentation must be included to enable a handover to a new service provider or internal teams (i.e., documentation that specifies the specific settings or developments made for the customer). The obligations in terms of procurement must also be clearly spelled out.
  - Internalize part of the maintenance/ administration and increase the ability to challenge requests and quotes for change from the provider.
  - In addition to standard maintenance clauses, contracts must contain the terms and conditions for carrying out upgrades and prenegotiated work packages on these various items.
  - As far of possible, it is recommended that proprietary frameworks be avoided as they limit the capacity to evolve and also the ability to find competent experts. They also tend to have inflationary tendencies on budgets.

3. **How not to lose sight of the final objective and guarantee the performance to be achieved?**

This capacity is intimately linked to the intrinsic complexity of purchasing and the ease with which it is possible to specify indisputable performance objectives with the supplier(s). Some technologies are a mix of instrumentations, communication networks, software, data storage tools, and data management consultants. It quickly becomes easy to lose track and no longer be able to ensure consistency in the choices between them (GIS, the IoT, and blockchain, for instance). Some technologies also require a great deal of internal coordination to prioritize and agree on functional requirements (SaaS, GIS, RPA/IA). Considered criteria to establish the risk rating include the value actually delivered by the tool after one year of use, level of exploitation of the technology put in place, proportion of recipients using the tool on a regular basis, and so on.

Figure 42. Procurement Complexity



- **Good practices to consider:**
  - Carry out a preliminary study to prioritize needs (cost/benefit ratio) and to define realistic implementation strategies. These studies will make it possible to define a more realistic trajectory and to make a better assessment of the difficulty of the various projects.
  - Formulate the needs in terms of functionalities and performance rather than in terms of solutions. Select tendering procedures that allow for consideration of different ways of serving the need.
  - Use the services of specialized consultants in the strategy preparation, bid evaluation, and implementation phases. The selection of independent and specialized project management assistance is quite decisive. The latter must have seasoned expert consultants with in-depth business knowledge and successful implementation experience at controlled costs.
  - The composition of the different implementation levels is also important. The project committees act as the first level and ensure that the various workshops are conducted on time and that commitments are met. A second level of authority is empowered to take decisions on the orientation of the chosen solution: choice of management rules, validation of the final models, and budgetary monitoring of the project.

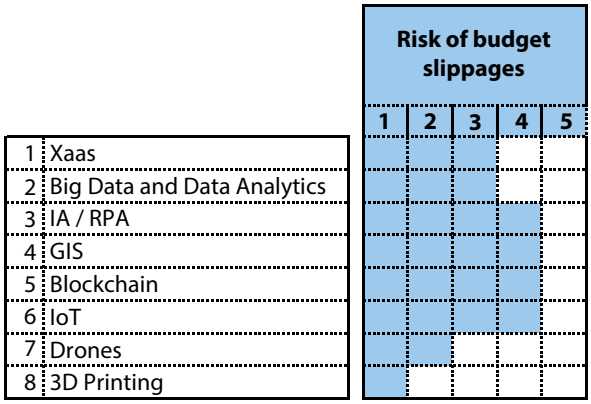
4. **How to control project costs and overall TCO?**

Budget slippage has multiple root causes and spares no technological choice. Some technologies present a higher risk because their implementation is demanding or subject to high risks. One considered criterion is the discrepancy level between planned and actual costs.

Good practices to consider:

- In order to minimize risks, it is better to start small with pilot projects and invest progressively according to the roll-out plan. It is even recommended that it is best to start with a POC (a prototype project) on a limited functional or organizational scope. Concurrent with the verification of certain functionalities, the POC will enrich the working group's field approach. It is then much easier for the buyer/prescriber binomial to identify the real cost drivers of the project and to challenge the prices given by suppliers. POC also makes it possible to get people and resources on board for further development and to gauge the user's reaction to what is being implemented.
- Retain project management assistance that is able to find workaround solutions that stay within the standard of the selected technological product. The target is to avoid having to undertake "custom" adaptations that are costly to build and develop.
- Adapt purchasing strategies (division into technical lots, options, form and duration of the contract, etc.).
- Favor lump-sum commitments. Limit fees based on time spent to what is strictly necessary or on a temporary basis (before being able to calibrate units of works, for instance).
- Think in terms of TCO over the life cycle or even in terms of TVO,

Figure 43. Risk of Budget Slippages



and define the selection criteria accordingly. For instance, a higher initial acquisition fee may in some cases be largely justified by the ability of the technical solution to be adapted to fit better over time.

- Strengthen the clauses and the system for monitoring contractual execution and measuring gains.

5. **How to ensure the availability of skilled resources over time on emerging technologies or manage the skills shortages?**

On some technologies such as blockchain, there is clearly a shortage of qualified engineers capable of conducting implementation projects. On the whole, for most of the technologies considered, there is fierce competition for qualified resources. Risk levels given below are assessed based on the remuneration levels of engineers who have mastered the technology.

Figure 44. Scarcity of Resources

		Scarcity of resources				
		1	2	3	4	5
1	Xaas					
2	Big Data and Data Analytics					
3	IA / RPA					
4	GIS					
5	Blockchain					
6	IoT					
7	Drones					
8	3D Printing					

Good practices to consider:

- Include clauses to ensure that skills are made available over the long term (project and everyday life). The market study carried out by the buyer must not only focus on the stability and interest of a solution but also on the ecosystem that enables its implementation. In other words, both the technology supplier and its ecosystem are selected as partners, if the latter is not itself in charge of integrating its technology with customers. The availability of qualified resources on a product must clearly be a criterion to be taken into account when defining purchasing strategies. These strategies must also allow for the consideration of bi-source framework agreements whenever possible, that is, to retain two suppliers in a framework agreement in order to be able to distribute the workload more evenly.
- Facilitate access for SMEs, in particular by defining application criteria that do not exclude them unnecessarily. Large-scale public projects can also lead to the emergence of new local players or the grouping of several local players among themselves or with foreign companies. The "upstream stimulation" stages prior to the publication of calls for tenders must also serve to encourage this type of approach.
- As far as possible, include in the contracts an obligation to transfer know-how on the administration and first-level maintenance of the technological solution, enabling the customer to be autonomous in day-to-day operations.

6. **How to foster user adoption?**

The widespread diffusion of an innovative technological solution requires a structured approach to change management. The complexity of driving change is clearly proportional to the diversity of profiles and the number of users that are impacted by the technology's implementation. They are also linked to the number of process/routines that the technology modifies (the case of SaaS software). To evaluate the potentiality of adoption issues, the duration of project implementation and the level of acceptance among the tool's initial recipients have to be considered.

Good practices to consider:

- Define bid evaluation criteria that are not only "technical" but also allow the buyer to assess the vendor's ability to actually deploy its technology.
- Beware of implementing solutions

Figure 45. Adoption Issues

		Adoption Issues				
		1	2	3	4	5
1	Xaas					
2	Big Data and Data Analytics					
3	IA / RPA					
4	GIS					
5	Blockchain					
6	IoT					
7	Drones					
8	3D Printing					

that are too complicated for users to handle, because it will then be necessary to break and rebuild in a simpler way.

- Conduct a real evaluation of the impact of technology on the various players and their functions in the purchasing chain: new roles generated by the technology, day-to-day routines that are likely to be modified, the main areas of "reluctance" per profile, new purchasing procedures or skills to be assimilated or reinforced, and so on. It is then necessary to anticipate all these actions to ensure the change management for the different profiles: training, repositioning, self-training tools, communication channels, and so forth.
- Involve end users and middle management as early as possible, as this will be a key link to promoting interest in the technology and counteracting the inevitable reluctance at the time of deployment.
- Participate in user clubs to share feedback on and approaches to encouraging adoption.

VI. EXAMPLES OF DISRUPTIVE TECHNOLOGIES USED IN THE PUBLIC SECTOR

The purpose of this chapter is to illustrate through concrete examples the benefits that are described in chapter IV. Although examples of successful implementation in public procurement are still rare for some of the considered DTs, such as blockchain or 3D printing, the recent COVID-19 crisis has confirmed that they can be a source of real value creation for procurement organizations, which is shown by the case descriptions described below.

The use cases have been selected based on interviews with public procurement professionals (see chapter X) and additional research. The selection is intended to show the diversity of successful uses that can be made of each of the technologies under study in various economic, geographic, and institutional contexts.

Some of these case studies have already been the subject of a report commissioned in June 2019 by the European Commission:[18]

- El Paso City Council (United States) – Chatbot to help procurement services
- New South Wales (Australia) – Categorization of procurement spending
- Dozorro (Ukraine) – Identification of potential wrongdoing in tenders
- Federal Ministry of Economy (Brazil) – Enhancement of spend analysis capabilities to build relevant strategies
- Federal Acquisition Service (United States) – Assessment of vendor compliance and eligibility to do business with the government
- U.S. Department of Health and Human services (United States) – Rationalization of the contract award process
- Seoul district of Yeongdeungpo-gu (Korea) – Evaluation of public tenders
- State Government of Jalisco (Mexico) – Evaluation of public tenders
- Some of the figures and lessons learned may differ from those proposed in the European Commission's report, not least because of the time interval between the two publications, which has given the authors of the present report a greater perspective on the projects observed.

USE CASES RELATED TO CLOUD COMPUTING AND XAAS

CASE #1 - STATE OF MARYLAND (UNITED STATES) - AUTOMATE THE FULL SOURCE-TO-PAY PROCESS

Electronic procurement solutions to buy products and services have been in existence for several years, though state and local governments for the most part have not been very motivated

[18] Deloitte, "Study on Up-Take of Emerging Technologies in Public Procurement," D01.06: Final Report (Brussels: European Commission, 2020), https://joinup.ec.europa.eu/sites/default/files/news/2020-06/D.01.06_Final_report_v3.00.pdf.

to change their procurement methods. In fact, citizens generally do not mind how the government buys products and services if they are not too expensive and do what they are supposed to do. Nonetheless, according to the U.S. National Association of State Procurement Officials, e-Procurement systems today are becoming more popular because they fulfill several of the needs and objectives of procurement officials.

To modernize and automate its processes, the U.S. state of Maryland decided to develop a system with software company Ivalua to streamline the procurement process and make it easier for businesses to participate while ensuring that all procurement procedures are conducted consistently, securely, efficiently, and impartially. State officials decided to select Ivalua's source-to-pay platform because of its success in the public sector in North America.

For Maryland, this solution has enabled more efficient state business procedures by automating the approval process, providing electronic invoicing, and eliminating redundancies in a highly secure and configurable system capable of integrating with other state programs. With this e-Procurement system, the state can improve transparency, boost competition, expand agencies' supplier base, maintain financial controls, measure performance, and promote efficiency in workflows.

The project was fully deployed in 2019. Since then, 825 procurement professionals have been trained and more than 12,000 vendors have preregistered in the procurement system to do business with the Maryland government. Vendors can benefit from its easy-to-use, single access point platform to review and participate in sourcing opportunities across the state. Procurement officials, for their part, can benefit from the centralized procurement and standardized practices across all agencies and departments, boosting efficiency in the procurement process. In addition, the solution will be available for use by state agencies, local governments, municipalities, and various players within the education system.

The political will to modernize the procurement function, along with the knowledge of public procurement among selected vendors, is expected to help the deployment and automation of the full source-to-pay process. Meanwhile, the integration of the solution into all procurement entities is a challenge that must be met for a successful implementation.

CASE #2 - PUBLIC PROCUREMENT SERVICE (KOREA) - AUTOMATE THE FULL SOURCE-TO-PAY PROCESS

The deployment of technological solutions in the field of procurement can be enhanced when they really are "end-to-end." This means that from the purchase requisition to the final payment of the invoice, all activities are traced and performed in the same system.

This was the agenda Korea developed from 1997 to 2002, in a long-term strategy to modernize its procurement system. This led to the deployment of KONEPS in 2002, which was immediately acclaimed by the United Nations Division for Public Economics and Public Administration as the winner of the United Nations Public Service Award for that year.

KONEPS has enhanced the transparency of public procurement in two ways: by publishing procurement information and by diminishing the possibility of corruption. Bidding information is announced on a real-time basis, stimulating genuine economic competition and reducing the number of private contracts in favor of e-bidding. The Public Procurement Service of Korea has announced that "the number of bidders has tripled as a result of decreased transaction costs and increased opportunities of eProcurement." Furthermore, the platform acts as the intermediary between public buyers and suppliers, so the number of interpersonal contacts has also been reduced.

Sharing business opportunities on a larger scale than before, KONEPS also stimulates the private sector by encouraging companies to do business on the internet. Korean businesses were consequently early adopters of tools such

as digital signature to secure and authenticate their bids.

Over time, KONEPS introduced new features based on innovations detected on the market (such as a fingerprint recognition system, a subcontract management system, open APIs, and more recently, a big data-based decision-making support system), following a strong focus on covering most of spend, most organizations, and most suppliers. In 2018, 55,000 public organizations and 400,000 suppliers were participating in the system, eliminating red tape, corruption, and time wasted.

KONEPS was exported to Vietnam in 2010, Mongolia and Costa Rica in 2012, Cameroon in 2014, Tunisia in 2015, Rwanda in 2015, Jordan in 2017, and the Kurdistan region of Iraq in 2019. The adoption of the system has proved costly and time-consuming in some countries, due in particular to a lack of coordination among public institutions and poor data availability. In general, however, it is still considered positive. In Vietnam, a 2014 evaluation report determined that the introduction of KONEPS had generally been successful.[19]

CASE #3 - COLOMBIA COMPRA EFICIENTE (COLOMBIA) - AUTOMATE THE FULL SOURCE-TO-PAY PROCESS

As many as 6,500 Colombian public entities were doing their purchasing independently of each other until they deployed the e-Procurement SaaS solution Coupa. In 2012, Colombia Compra Eficiente (Colombia Buys Efficiently, or CCE) was created to boost efficiency in spending across all entities. Obtaining better VFM, improving the standardization of purchasing procedures for more than 20,000 expected users, and leveraging reductions among vendors define the objectives of CCE.

Currently, CCE is supplying Coupa's PTP apps for numerous entities, such as the Colombian military, hospitals, and the Ministries of Defense and Foreign Affairs. Moreover, Coupa will be used to procure fuel, vehicle insurance, cleaning services for offices, hardware, surveillance programs for public buildings, and IT services.

CCE chose Coupa's solution for its easy-to-use, scalable, and best-in-class cloud technology, enabling the public procurement process to be more efficient and giving the Colombian government greater supervision of, and more control over, its spending. More than 400 public officials are already using it, and with its uncomplicated interface, user adoption is expected to grow significantly to up to 20,000 users across 6,500 entities over the next two years. The allocated budget to implement the solution is US$853,550, expecting a counterweight of US$1 billion savings in procurement spending.

The e-Procurement SaaS solution was fully deployed in 2014, with the aim of decreasing the time spent by procurement officials in allocating purchase orders from close to three months to roughly just one hour, improving efficiencies for the entire Colombian government, and making Coupa the foundation of the successful CCE initiative.

USE CASES RELATED TO BIG DATA ANALYTICS

CASE #4 - STATE OF NEW YORK (UNITED STATES) – ENHANCEMENT OF SPEND ANALYSIS CAPABILITIES

In the U.S. state of New York, public authorities are required by Section 2800 of the Public Authorities Law to submit annual reports to the Authorities Budget Office that include procurement contract data. More specifically, the dataset consists of procurement contract data reported by state authorities beginning with fiscal years ending

[19] KOICA and World Friends, "Ex-Post Evaluation Report on the Project for Establishment of an E-Procurement Pilot System in Vietnam (Seoul: Korea International Cooperation Agency, 2013), https://www.oecd.org/derec/korea/Ex-post-Evaluation-Report-on-the-Project-for-Establishment-of-an-E-procurement-Pilot-System-in-Vietnam.pdf.

in 2011. Authorities are required to report procurement transactions that have an actual or estimated value of US$5,000 or more.

This accumulation of data[20] has helped New York to analyze its purchasing records and to use those insights to build cost-efficient strategies that corresponds to the first STC process related to the development of a purchasing strategy. Leveraging a massive amount of data (big data refers to a volume of data that is so large it is difficult to process using traditional database and software techniques) can help to unlock the hidden potential for **cost savings in public procurement**.

Indeed, New York, through the use of big data analytics, is now analyzing its purchasing data and utilizing the results to increase its purchasing volume from a fewer number of suppliers to enable discounts.[21] By leveraging public procurement data and this specific strategy, it is estimated that the state has saved **US$780 million over five years on purchases across 47 different categories.**

Areas where this data-driven approach have been beneficial include such purchases as office supplies, IT hardware and software, telecommunications, facilities, fleet and vehicle purchase and maintenance, advertising, travel expenses, and medical products.

Big data analytics have enabled the state to negotiate better deals as a result of decisions based on past purchasing data. Moreover, the use of big data analytics has created a greater transparency in all public procurement key metrics, such as detailed spending per product, deals negotiated, and so on.

The project in New York has been successful because of several factors. First, the availability of a wide variety of data sources (the project depends on the digital records of public procurement tenders) and APIs. Second, the analytical capabilities that enabled the procurement function to unlock the real value of large amounts of structured and unstructured data also played a significant role.

When it comes to potential roadblocks, the lack of data is crucial. The success of a big data analytics solution highly depends on the amount of data at the disposal of a given public procurement organization. In New York, the legal framework helped build a solid dataset composed of different data sources. Finally, the importance of political will should not be underestimated. Indeed, in the case of a country like the United States, the fact that mayors appoint chief data officers and chief performance officers and charge them with using data to deliver better service to the public is a positive dynamic.

CASE #5 - DEPARTMENT OF LOGISTICS, STANDARDS AND SYSTEMS OF THE SECRETARIAT OF MANAGEMENT – MINISTRY OF ECONOMY (BRAZIL) – ENHANCEMENT OF SPEND ANALYSIS CAPABILITIES TO BUILD RELEVANT STRATEGIES

In Brazil, it is legally mandatory to conduct price research as a preparatory task before launching a public procurement procedure. However, it is difficult to operationalize this task. The previous system proved to be inefficient and very time-consuming. Furthermore, it was built on multiple programming languages, so the stored datasets could not be compared to one another. This meant that although data were available, there was no transparent way to track all of the previous prices. As a result, public officials had limited access to the information that was stored.

In July 2017, the Brazilian authorities selected a business intelligence application developed by the company Qlik. This application enables public procurement professionals to research, analyze, visualize (thanks to data visualization), and compare the prices paid by the federal government since 2015 in the purchasing of materials and

[20] New York, State of, "Procurement Report for State Authorities," https://data.ny.gov/Transparency/Procurement-Report-for-State-Authorities/ehig-g5x3/data.
[21] J. Wiseman and S. Goldsmith, "Ten Great Ways Data Can Make Government Better," Data-Smart City Solutions, May 11, 2017, https://datasmart.ash.harvard.edu/news/article/ten-great-ways-data-can-make-government-better-1041.

services. All information on purchases made and approved was recorded in a unique database.

For instance, a search for the price of a given item used to bring up many results. This situation created a considerable amount of guess work rather than data-driven decisions. There was also a higher risk of purchasing overpriced goods or services. The Qlik dashboard changed this by standardizing the data so that officials can easily search and compare all costs, thereby ensuring that they pay suppliers the right prices.

This Price Dashboard powered by big data analytics was integrated into a public portal. Analysis and visualizations were developed in Qlik Sense® and integrated into the website with the Qlik Analytics Platform. This integration allows the Price Dashboard to be totally responsive, enabling nontech officials to access it through any type of device.

Before the launch of the portal, roughly 90 percent of federal public agencies did not have access to the government's price database. Unfortunately, when it was time to raise budgets for a bid, the estimated prices were well above market value and agencies were at risk of overpaying.[22]

Today, in addition to ensuring total transparency, the new Price Dashboard facilitates fixing budgets and marking prices, which allows public procurement professionals **to buy faster at a lower price and with greater transparency.** This same transparency has led to a reduction in contract prices, generated by broader and more transparent competition. Moreover, the new interface has significantly reduced the time needed for public officials to research prices: **it used to take up to 20 days but now takes an average of 11 minutes.**[23]

In this case study, several elements helped the Brazilian authorities. First, the existence of a platform called SIASG/Comprasnet, which recorded all information/data on purchases made and approved. Second, the project had the support of the Brazilian government. However, no open source tool has been identified that can perfectly meet the expected dynamics of the product.

It should also be mentioned that qualified solution users should be engaged as early as possible to avoid future rework and redesign issues. For these solutions, a certain level of dashboard customization is key.

CASE STUDY RELATED TO ROBOTIC PROCESS AUTOMATION

CASE #6 - FEDERAL ACQUISITION SERVICE (UNITED STATES) – ASSESS VENDOR COMPLIANCE AND ELIGIBILITY TO DO BUSINESS WITH THE GOVERNMENT

Recently, the U.S. government[24] underscored RPA's potential to make government more efficient and called on agencies to start exploring potential applications. As a result, the Federal Acquisition Service (FAS) began to reflect on how RPA could help procurement. As of today, the FAS has created several bots[25] (using technologies such as the one developed by UiPath[26]) that can, for instance:

[22] "Brazilian Ministry of Planning Ensures More Transparency in Government with Qlik," https://www.qlik.com/us/company/press-room/press-releases/0712-brazilian-ministry-of-planning-ensures-more-transparency-with-qlik.
[23] Qlik, "How Brazil Eliminated Overpriced Procurement with Data," GovInsider, January 2020, https://govinsider.asia/innovation/qlik-ministry-of-planning-how-brazil-eliminated-overpriced-procurement-with-data/

[24] J. Corrigan, "How GSA is Helping the Government Embrace Automation," Nextgov, April 22, 2019, https://www.nextgov.com/emerging-tech/2019/04/how-gsa-helping-government-embrace-automation/156463/.
[25] J. Heckman, "How GSA Turns an Automation Project into an Acquisition Time-Saver," Federal News Network, March 29, 2018, https://federalnewsnetwork.com/technology-main/2018/03/how-gsa-turned-an-automation-project-into-a-acquisition-time-saver/.
[26] M. Leonard, "Agencies See Big Upsides to RPA," GCN, April 24, 2018, https://gcn.com/articles/2018/04/24/agency-rpa.aspx.

- Validate whether a vendor is eligible to do business with the government. **This task in the past took a contracting officer 15 minutes but today takes only 10 seconds.**
- Pull information from vendor offers on websites and populate them into a prenegotiation memo. **This task in the past took a contracting officer 22 minutes but today takes only 20 seconds.**

The results were overwhelmingly positive (the General Service Administration [GSA] has implemented 25 RPA bots so far[27]), and thanks to this application, FAS' contracting specialists can now spend more time on value-added activities. Indeed, the main idea of RPA is to save the workforce from wasting time on administrative tasks. In the context of public procurement, that would mean more time to focus on contract negotiations and stakeholder engagement.

Despite these obvious advantages, an RPA implementation must be done cautiously. For many people, automation means unemployment. For this specific reason, several hours of training are required to explain the benefits of this technology and eliminate potential fears. Moreover, RPA cannot be considered a one-size-fits-all solution. Different public procurement might have different processes; therefore, it is key to spend time in the customization of an RPA bot.

Indeed, if the existing overall procurement process lacks efficiency, RPA will not fix the root issue. Justin Herman, then-head of GSA's Emerging Citizen Technology interagency program said, "If you're just taking a broken, old process and slapping RPA on it, all you're going to have is a faster broken process."

Furthermore, it is key to remind public procurement professionals that the best RPA projects should be rules-based (most suited for RPA) and have a high potential for impact through automation (e.g., because it is highly time-consuming to perform the tasks manually).

These two criteria are not hard to meet in many STC steps, such as the management of the tendering process, offer evaluations, assessment of supplier compliance and risks, and so on. Moreover, IT security risks should not be underestimated. The possibility of unplanned actions by bots is something to consider, as well as any potential internal concerns regarding the actual value added from RPA-based solutions.

CASE STUDIES RELATED TO ARTIFICIAL INTELLIGENCE

CASE #7 - EL PASO CITY COUNCIL (UNITED STATES) – CHATBOT TO HELP PROCUREMENT SERVICES

AI can help public procurement in many steps of both STC and PTP. However, AI can also go one step further and improve the entire experience of dealing with public procurement authorities as procurement professionals. In this context, the Purchasing and Strategic Sourcing Department of the El Paso City Council in the U.S. state of Texas decided to improve customer service by creating an avatar called Ask Laura (developed by "Living Actors"[28]), modeled on a city deputy attorney.

The idea was to let AI handle basic purchasing questions through a chatbot. A chatbot can be defined as a computer program designed to simulate conversation with human users, especially over the internet. The ability to have human-like conversations is the result of an AI subset called NLP. Even though chatbots are slowly becoming a mainstream solution for business to consumer (B2C) companies, it is

[27] "GSA Puts Bots to Work in Bulk," GCN, October 31, 2019, https://gcn.com/articles/2019/10/31/psi_gsa-rpa-program.aspx.

[28] For more information, see https://www.livingactor.com/Assistant/.

still highly unusual to be adopted by a public organization, despite the obvious advantages.

By using NLP algorithms, the goal is to identify and extract the natural language rules such that the unstructured language data is converted into a form that computers can understand. From a user perspective, Ask Laura provides immediate information on topics that include:

- How to register as a vendor with the city
- How to do business with special programs
- Where to find bids and other FAQs

The city deployed the solution in early 2017 and according to city officials,[29] the technology has already been very positive for the purchasing department. Indeed, the main objective was to increase process efficiencies in delivering support via the website in order to save employees time and ensure that vendors receive a fast and personalized answer to their inquiries.

The cost for the first year, involving the purchase and implementation of the software, was US$20,140, which is significantly less than hiring a full-time employee. Moreover, **the city estimates that it saves some US$26,000 per year**. The solution comes with its own analytics and allows the department to update any questions that need to be answered.

Additionally, AI-powered chatbots can help retain a significant amount of data and bring clarity to answers for any procurement-related need. The analysis of the data collected through the chatbot can reveal patterns and help procurement authorities better understand how users interact with related websites. Furthermore, the solution makes the procurement service desk available outside operational hours.

The solution does require regular maintenance. Indeed, the accuracy over the long term can be guaranteed only through the implementation of a continuous learning process. These solutions are made easier, however, with the assistance of procurement experts who can be consulted in the development of a knowledge base.

CASE #8- NEW SOUTH WALES (AUSTRALIA) – CATEGORIZATION OF PROCUREMENT SPENDING

When it comes to using AI in the STC process of developing a purchasing strategy, the following use case is notable.

Australia's New South Wales (NSW) procurement team was required to manually categorize 2 million procurement transactions every quarter, according to NSW's government procurement taxonomy. This was a necessary task in order to provide insight into government spending, but it was a time-consuming and tedious process for analysts, using up 160 employee days every year. Spend data categorization is often achieved through a manual process that is prone to human inconsistency and biases and is difficult to use because of the need to utilize all key data fields to accurately categorize spend.

In 2017, NSW procurement decision makers, with support from the Data Analytics Centre, developed a machine learning tool called CAITY that **automatically categorizes different types of procurement spending based on data extracted from general ledger data**. The solution was developed using Python-based machine learning tools provided on the Microsoft Azure public cloud.

The previous manual classification process had an accuracy rate of about 70 percent. After being trained on over 45 million rows of pre-classified data, CAITY has now achieved a 97 percent accuracy rate on procurement spend categorization. Moreover, the team has managed to eliminate human bias by replacing more than 1 million mapping rules that were cumbersome to maintain, allowing analysts to focus on the transactions and minimize mistakes. Ideally, they plan on having a solution that can be applicable to other tasks involving categorical data by creating a user-friendly interface and a transferable model.

[29] E. Zima, "Meet El Paso's Chatbot, Ask Laura: She's a Real Game Changer," Government Technology, December 20, 2017, https://www.govtech.com/dc/Meet-El-Pasos-Chatbot-Ask-Laura-Shes-a-Real-Game-Changer.html.

This case study teaches us that the success of machine learning (a subset of AI that can find patterns in massive amounts of data[30]) highly depends on the availability of the relevant training data (historical spend data). In NSW, the procurement organization already went through a data maturity process by previously implementing a data collection strategy and analytics tools and leveraging open data. The modernization process took four–five[31] years to be completed and ready for an AI integration.

Using AI requires the presence of technical specialists (data scientists) for maintenance. The initial setup phase was heavy and required the support of decision makers over the long term as well as an internal data science team. As with many DTs, issues still remain. In this case, NSW procurement is still struggling with lower prediction rates on new as opposed to existing vendors, uncompliant data, and the lack of validated training data.

Despite these technical issues, NSW procurement continues to invest in CAITY and plans to further develop the solution by enhancing its machine learning models to integrate a taxonomy project, expand category dashboards, and develop new agency dashboards. NSW procurement also intends (Vision 2021) to leverage data-driven solutions to drive its procurement strategy, derive actionable insights, provide spend analytics support, publish data on the NSW website, and finally, demonstrate transparency.

CASE #9 - DOZORRO (UKRAINE) – IDENTIFICATION OF POTENTIAL WRONGDOING IN TENDERS

AI's ability to analyze documents can help the STC step of awarding contracts. Unfortunately, many countries are struggling with corruption, which significantly impacts public procurement. In order to fight corruption related to public tenders and the limitations of Ukraine's existing public procurement process (using an e-Procurement system called Prozorro[32]), Transparency International Ukraine created AI to detect issues with public tenders and to highlight suspicious cases.[33]

In 2018, the organization unveiled an AI program, based on machine learning algorithms, that independently assesses potential corruption risks in tenders and then sends them to civil society organizations of the DOZORRO users' community. If the action was in fact suspicious, the software remembers its choice; if the action was not and the software was wrong, it forgets it. This way, the AI algorithm's assessment of potentially risky tenders becomes increasingly accurate. The AI has benefited from the fact that the existing Prozorro system contains details of 1.14 million tenders and 1.61 million reports on direct purchases. As such, anyone skillful enough can build independent analytical systems on top of it.[34]

The solution was created to strengthen and also highlight the weakness of the current e-Procurement system, which is based on a defined list of risk indicators. These indicators include violations of the bidding procedure, bidding participants unable to participate, violations of review deadlines, and a large quantity of lots included in one tender, as well as the absence of digital signatures, a concluded agreement, uploaded tender documentation, and a description of the procured item.

The more indicators that are flagged, the greater the chance that the tender will be verified by the auditors. **The DOZORRO system, on the other hand, is more flexible and does not**

[30] K. Hao, "What is Machine Learning," MIT Technology Review, November 17, 2018, https://www.technologyreview.com/2018/11/17/103781/what-is-machine-learning-we-drew-you-another-flowchart/.
[31] New South Wales, Government of, "Curious Case of CAITY: Artificial Intelligence in NSW Procurement," https://spb.sa.gov.au/sites/default/files/1.%20Artificial%20Intelligence%20in%20NSW%20Procurement%20-%20PDF.pdf.
[32] See https://prozorro.gov.ua/en.
[33] "Dozorro Artificial Intelligence to Find Violations in Prozorro: How It Works," Transparency International, November 2, 2018, https://ti-ukraine.org/en/news/dozorro-artificial-intelligence-to-find-violations-in-prozorro-how-it-works/.
[34] A. Kucherenko, "AI Watchdog for Public Procurement" (Blog), January 22, 2019, https://medium.com/@andriykucherenko/ai-watchdog-for-public-procurement-730411ad66fe.

have an exhaustive list of indicators. It took roughly one year to develop a full solution. The DOZORRO AI enables activists to identify fraud in public procurement much faster and report their findings to supervisory and law enforcement agencies. These activists all use a nongovernmental monitoring portal aimed at supporting the integrity of public procurement.

Thanks to the algorithm, 26 percent more tenders with unfounded winner selections have been identified, 37 percent more tenders with groundless disqualifications, and 298 percent more tenders with participant collusion. It is noteworthy that the AI found the most violations in the most expensive tenders. **More than 20,000 violations have been identified by the community since the project's launch.**

The success of this case study highly depended on the availability of data to train the machine learning model. **The model was fed thanks to the 3,500 tenders checked by independent activists** who were asked whether they found any risks. To make their assessment as objective as possible, the experts did not know the amounts or the names of the procuring entities.

Lastly, expectation management is also a key issue. Indeed, according to Andriy Kucherenko, Product Manager at Dozorro, "no AI will ever be able to identify violations in tenders better than experts do. But AI algorithms will make their work much more efficient." This project highlights the need for engaged citizens with both a public procurement and technical background who are willing to spend time fighting corruption.

CASES STUDIES RELATED TO GEOTAGGING AND GIS

CASE #10 - WESTMINSTER CITY COUNCIL (UNITED KINGDOM) - MAP THE NEED TO DEFINE THE MOST RELEVANT STRATEGY

To maximize the taxpayers' VFM related to waste disposal, the Westminster City Council in the city of London undertook an innovative approach to better determine the selection criteria in its tender documents for new contracts. By doing so, the Council identified a £2 million savings potential.

As the two main contracts for waste disposal and recycling were coming up for renewal, the Council's sanitation department wanted to make sure that its £225 million budget allowance would offer its citizens the best possible service from the newly selected suppliers as they dealt with the 190,000 tons of rubbish generated every year. The starting point was to identify the main cost drivers behind the historic expenditure. Given the soaring fuel prices and growing congestion in London, it became clear that the travel to and from recycling facilities, waste treatment sites, and vehicle depots was an important factor in the cost of waste disposal services.

In this respect, the main challenge consisted of accurately measuring the drive times at various times of the day while considering alternative routes if streets were usually busy. After an unfruitful drive-time analysis made by an external transportation consultancy that cost the Council £20,000, the sanitation department realized that its internal GIS could effectively address the challenge.

The Council carried out its analysis by combining the network routing data for central London with the online version of its GIS, which allowed it to create an initial POC to determine a car's average drive time. GPS data from its waste collection trucks were subsequently incorporated into the platform, which gave actual, average speeds of its own fleet at various moments of the day.

As an outcome of the analysis, the Council's sanitation department produced an online map that was included in its tender documents with the aim of considering bids from suppliers with sites located within a certain range. This new approach allowed the Council not only to optimize the operation of waste collection vehicles, but also to set relevant criteria to enhance fact-based decision making for the

choice of new contractors. This has had an unequivocal impact on the amount of money spent.

CASE #11 - MINISTRY OF RURAL DEVELOPMENT (INDIA) - GEOTAGGING AND MAPPING OF ASSETS

As a result of public outcry related to the misappropriation of common funds, and after public declarations from the Indian Congress, in 2016 a public call was made to record and monitor assets to check for leaks. The Indian government suggested the launch of a process that would effectively map terrain through geotagging, which would enable the sharing of such information as videos or photos among various media.

Geotagging was created under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) framework. It generates an asset ID on the National Rural Employment Guarantee Act (NREGA) software after work is completed and marks it as a primary asset. All the geotagging of assets is done through the Bhuvan mobile network. This platform also works using GPS to identify the location of the asset in question.

All data collected are validated by officers known as "GIS asset supervisors." Afterwards, before finally registering the data in the Bhuvan portal, a state nodal officer approves its display in the public domain. Beginning in April 2017, whatever work is completed must be geotagged within 30 days.

In addition, a citizen mobile app was launched in June 2017. "Janmanregah" enables citizens to locate geotagged assets on the Bhuvan app and provide their feedback. So far, almost 30 million (3 crore) assets have been tagged though the app. All works are monitored by geotagging before, during, and after completion to guarantee 100 percent transparency. Now, every asset under MGNREGA is properly tagged and available in the public domain for audit.

Further ensuring transparency, the GeoMGNREGA app is handy for states and union territories to efficiently plan works on a site. It also helps to avoid duplicating projects while still working within the budget.

CASE STUDIES RELATED TO BLOCKCHAIN

CASE #12 – U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES (UNITED STATES) - STREAMLINING THE CONTRACT AWARD PROCESS

The U.S. Department of Health and Human services (HHS), as is the case with many government agencies around the world, is seeking new tools that rely on advanced technologies in order to operate more efficiently and thus serve citizens better. One such effort can be illustrated with the creation of a global, transverse database to derive insights even when data come from different systems without interoperability.

HHS, with over 1 million contracts issued in the past 18 months from five different existing contract systems believe that aggregating the data would provide procurement officers with a powerful tool to drive costs down. To do so, HHS has opted for a blockchain approach that allows it to layer each contract system and to repatriate all contracts onto the new platform. The goal is to keep all contract systems operating while creating a separate platform alongside them to modernize business procedures and create analytical insights for the people negotiating HHS contracts.

The contracts are subsequently handled by an AI model grafted onto the platform in order to screen all contracts, identify prices, and list the scope of terms and conditions using NLP and machine learning. This task, which would take a human several months to complete, can be performed in only a few seconds.

To confront the natural human resistance to change, which is often even higher within government agencies, the team in charge of implementing the app were looking for user buy-

in to make the user experience better. One of their findings was to pre-populate as much information as possible that in the past would have been input by users, with the purpose of streamlining the contract award process.

Another way to face the resistance to change is to embed the new platform, and therefore the new way of working, into the culture as soon as possible. Instead of hesitating about the best way to modelize a process or to deal with change management, prototypes and POC software are built and then calibrated over time to flatten the learning effort as much as possible and avoid any trauma.

Of course, any such platform is powered by algorithms that are fueled by data. And within HHS, the question of privacy plays a paramount role, especially the privacy of citizens. This explains the decision to start with procurement in order to improve the purchasing process, which, in turn, increases taxpayer satisfaction.

CASE #13 - ARAGON REGION (SPAIN) - EVALUATE PUBLIC TENDERS

The regional government of Aragon in Spain decided to develop a regional digital economy with €12 million in funding, aimed at tackling the protection of intellectual property in industry and facilitating specialized consulting projects to boost the development of local SMEs and help fight corruption.

This project was co-financed with the European Regional Development Fund in order to develop 4.0 competences and associated technologies, digital solutions that cater to the needs of industry, and collaboration between companies and research centers.

The increasing level of corruption in Aragon led the authorities to leverage the use of blockchain to prevent it. With the help of Open Canarias/ Oesia, Quorum/Hyperledger Besu/HyperLedger Fabric, and Alastria, a new tendering solution was implemented and fully deployed in June 2019.

The goal of the solution was to evaluate the offers without the need for a trusted third party to encrypt them. The system consists of two parts:

- First, bids are registered on the system to collect the information.
- Second, data are interpreted so that suppliers' offers are automatically evaluated through the use of smart contracts on the blockchain, which guarantees the integrity and transparency of the information provided in public procurement.

By Disruptive Technologies in Public Procurement, one year after the official adoption of the solution, more than 25 tenders had been issued using this system.[35] Not only does this method boost the integrity and transparency of the information handled, it also improves project efficiency. Without the need for a trusted third party, data verification can be processed easily and immediately.

The project was introduced to address the needs of 320 companies based in the region. Simplified open procedures used for the award of contracts for works up to €80,000 and for services and supplies for up to €35,000 were the first to benefit from the blockchain system.[36] As a consequence of this implementation, SMEs are finding it easier to assimilate digitalization into their processes and products.

A project such as this can be successfully carried out provided that there is political support and the ecosystem of specialized companies in blockchain does not disappear. Negative attitudes toward blockchain and concerns about the privacy and security of public data are challenges that must be taken into consideration.

CASE #14 - SEOUL DISTRICT OF YEONGDEUNGPO-GU (KOREA) - EVALUATE PUBLIC

[35] IDB and WEF, "Exploring Blockchain Technology for Government Transparency: Blockchain-Based Public Procurement to Reduce Corruption" (Geneva, World Economic Forum, 2020), 14, http://www3.weforum.org/docs/WEF_Blockchain_Government_Transparency_Report.pdf.

[36] "The Government of Aragon Will Use Blockchain Technology to Receive Offers for Public Contracts, Aragon Hoy, January 9, 2019, http://www.aragonhoy.net/index.php/mod.noticias/mem.detalle/area.1020/id.236390.

TENDERS

The Seoul district of Yeongdeungpo-gu has created a transparent and trustworthy system for the evaluation of public tenders with the help of Glosfer. The need stemmed from the lack of transparency and trust in the awarding of public contracts, which were often contested by the losing competitors.

The aim of the district office was to digitalize the evaluation process, leveraging BCT to record the individual evaluation results in order to achieve the utmost transparency, integrity, and auditability of tendering procedures and to increase the convenience of evaluation committee members. The project, which is now fully deployed, was developed from July to October 2018 with an allocated budget of €115 000 (151,000,000 KRW).

The authorities had to face several challenges, such as the negative attitudes toward blockchain and legal regulations on BCT and the privacy and security of public data. However, the political will to select a blockchain-based solution, and the ability of public data experts to optimize implementation, countered the roadblocks to successfully launch and deploy the blockchain system in the district.

In fact, the blockchain project won the grand prize in the "Contest for Anti-Corruption Best Practices," which emphasized the results achieved with a blockchain solution.

CASE #15 - STATE GOVERNMENT OF JALISCO (MEXICO) - EVALUATE PUBLIC TENDERS

The National Digital Strategy Coordinator at the President's office in the Mexican state government of Jalisco promoted a hackathon to identify the scope for and implications of using BCT for public tenders. This project was encouraged by the digital context in Mexico, in which internet access has become a constitutional right and a Universal Digital Inclusion Policy derived from the National Digital Strategy has been established. From 2013 to 2016, internet users in Mexico increased by 41.28 percent, and the percentage of users using the internet to interact with the government rose from 1.1 to 22.2 percent.

The use of BCT in the public sector represents the possibility of providing highly secure and reliable digital services at low cost, based on open technology and a transparent process for all participants, which would significantly increase confidence in public institutions and more effectively fight corruption. If implemented, Mexico would be among the first countries in the world to have a documented use of blockchain and to be accompanied by international organizations such as the World Economic Forum, Inter-American Development Bank, OECD, United Nations Department of Economic and Social Affairs, and Economic Commission for Latin America and the Caribbean.

The two main benefits expected from the use of blockchain for public tenders are the prevention of bribery, thanks to anonymous voting and rating by certified evaluators, and civic auditing through citizen participation in the decision-making process.

Forty-two professionals were involved in the pilot phase that took place from April 2017 to November 2018. The winner project, presented by Hyperledger Fabric, is a blockchain system that allows the public tender process to be reliable, adding citizen participation and ensuring that the winner of the tendering process generates the greatest social benefit.

An evaluation has made clear the key risk factors. Any such project must take into account political changes, privacy risks from the processing of public data, cybersecurity concerns, and the need for an appropriately skilled workforce in the country. It should also highlight the importance of private/public collaboration to achieve a successful venture.

CASE #16 - PORT AUTHORITY OF VALENCIA (SPAIN) - MANAGE SHIPMENTS

In order to gain visibility within the supply

chain networks, the Port Authority of Valencia decided to join a blockchain initiative to provide an accurate and verifiable single source of information across global supply chain networks. This led to a project with the blockchain shipping platform TradeLens.

The TradeLens project was jointly developed by IBM and Maersk to apply BCT to the global supply chain. Using intelligent blockchain contracts, TradeLens allows digital collaboration between the multiple parties involved in international trade to simultaneously access a project in real time, enabling a single shared view of a transaction while protecting data privacy and confidentiality.

The commercial document module, launched under a beta program and called ClearWay, allows importers/exporters, customs agents, customs authorities, other government agencies, and nongovernmental organizations to collaborate on business procedures and the exchange of information between organizations, all supported by a secure audit trail. According to the data collected, the system will reduce shipping transit time by 40 percent and eventually digitalize the entire container shipping process.

The implementation of this BCT is estimated to save US$220 million a year for importers and exporters and up to US$40 million in lower transport and logistics costs. It is expected to achieve three benefits:

- Increase the efficiency of the logistics chain by giving each agent access to real-time information about the location and condition of cargo
- Improve transparency by making documents traceable and auditable
- Reduce the shipment transit time by 40 percent, resulting in substantial economic savings

The project was fully deployed in 2018, making the Valenica Port Authority one of many high-profile early adopters that collaborate on the technologies that originate from the program. The success of the project rests partly on the political will to join the platform and on the ability to process public data.

CASE STUDY RELATED TO DRONES

CASE #17 - GHANA HEALTH SERVICE (GH) – FACILITATION OF MEDICAL SUPPLIES AND VACCINES DELIVERY

Drone deliveries can impact the PTP step related to the receipt of goods and services. Indeed, in the following use case, it can be seen how this technology helped procurement authorities handle the "last mile delivery" issue.

In a four-year project starting in 2017, Ghana and the California-based drone delivery start-up Zipline embarked on a partnership to deliver drugs, blood, and vaccines by drone. Initially, the goal was to deliver these products only to remote areas, but recently, Zipline has started delivering to Accra, the nation's capital, and Kumasi, the second-largest city. This proves that drones can also be efficient in densely populated areas.

By leveraging the use of drones, the country intends to tackle the issue of last mile delivery, which many logistics operators face in African cities and rural areas where road networks are either underdeveloped or poorly maintained. Since 2016, the company's autonomous drones have flown more than 2 million miles and delivered more than 60,000 vaccines, units of blood, and other medical products in Ghana, Rwanda, and India. As of today, drones in Ghana will cover 2,000 health facilities within an 80-kilometer (50 mile) range.

Deliveries can be made directly from hospitals. Drones operate 24 hours a day throughout the week from four distribution centers, each of which is equipped with 30 drones to deliver essential medicines and blood products.[37] The system is expected to serve 14 million people across the country. The company has a contract with Ghana

[37] WHO, "His Excellency the Vice President of the Republic of Ghana Launches Ghana's Drone Delivery Service," April 29, 2019, https://www.afro.who.int/pt/node/11167.

to make 600 deliveries a day for four years at a cost of roughly US$12.5 million.[38] On average, the price per delivery is approximately US$14.

From a technical perspective, the drone can take off from its distribution center and land without requiring additional infrastructure. It can fly autonomously and carry 1.8 kilos of cargo, cruising at 110 kilometers an hour with an all-weather round-trip range of 160 kilometers. Zipline has been working with the U.S. Federal Aviation Administration on the necessary approvals needed to operate commercially in the United States and says that it could do so within weeks of receiving the go-ahead.

The overall success of this project can be explained by many elements. Political support played a significant role. Indeed, Ghana's Vice President Mahamudu Bawumia, at the launch, said the drone medical delivery service represented a major step toward giving everyone in the country universal access to life-saving medicines.

The project faced some popular resistance due to the technology's high cost. However, the capacity to execute multiple deliveries per day helped stakeholders understand how drones represent a proven improvement compared to traditional road delivery. From a public procurement perspective, drone delivery has helped Ghanaian authorities better manage delivery costs and increase efficiency.

CASE STUDIES RELATED TO 3D PRINTING

CASE #18 - NORTHWELL HEALTH, UNIVERSITY OF SOUTH FLORIDA, BETH ISRAEL DEACONESS MEDICAL CENTER (UNITED STATES) - TACKLE SHORTAGE OF MUCH-NEEDED MEDICAL SUPPLIES

During the COVID-19 outbreak in spring 2020, entire supply chains were disrupted by coronavirus control measures in some parts of the world, especially China and Western Europe. In particular, the medical devices called nasopharyngeal test swabs (used for processing polymerase chain reaction, or PCR tests) used on the American market are made mainly in China and Italy. These two countries were hard hit by the pandemic and shut down first, which meant that when the virus was starting to spread in the United States, stocks of test swabs could not be replenished, and the targeted testing capacity could not be met.

This material impossibility of procuring test swabs on the market was addressed in an innovative and disruptive manner by "sourcing" differently: via 3D printing. Within a few days, University of South Florida Health, in partnership with Northwell Health (New York, NY), and Beth Israel Deaconess Medical Center (Boston, MA), using 3D printers and autoclavable resins, developed prototypes that received a variety of hospital approvals and Class I Exempt status from the U.S. Food and Drug Administration (FDA). They were also held to be in compliance with the guidelines of the Centers for Disease Control. USF Health and Northwell Health hold the provisional patent for this technology but have shared the print file online with institutions around the country that have the FDA-cleared technology and materials to print their own swabs.[39]

As a result, a quicker and more cost-efficient testing capacity was greatly welcomed by public health officials: the target was to produce up to 4 million swabs per week. Excellent collaboration between public and private stakeholders helped run a smooth, yet transparent process from

[38] K. G. Asiedu, "An Ambitious Drone Delivery Health Service in Ghana is Tackling Key Logistics Challenges," Quartz Africa, April 25, 2019, https://qz.com/africa/1604374/ziplines-drone-delivery-launches-in-ghana-with-vaccines/.

[39] See https://printedswabs.org/.

conception to production. The existence of 3D printers across medical labs was also a factor in the program's success.

CASE #19 - PARC TAULI HOSPITAL (SPAIN) - TACKLE SHORTAGE OF MUCH-NEEDED MEDICAL SUPPLIES

Following the rapid expansion of the COVID-19 health emergency, a need for ventilators rapidly arose to save patient lives. 3D seemed to be the best solution to answer the emergency in a short period of time, especially to serve large hospitals such as the Hospital Parc Taulí. A consortium composed of Consorci de la Zona Franca (CZFB) and Leitat (Tecnio), together with CatSalut, Consorci Sanitari de Terrassa (CST), and Hospital Parc Taulí de Sabadell, managed to develop 3D-manufactured emergency ventilators that were approved by doctors and authorized by the Spanish Agency of Medicines and Medical Devices (AEMPS) for clinical trial. Parc Tauli Hospital was one of the first hospitals to receive the first respirator units along with other regional hospitals.

Producing these emergency ventilators in a limited amount of time was achievable because they are industrially scalable. 3D makes it possible to simply design all the components grouped in one piece to save time in the production phase. Thanks to this method, the alliance of companies can reach a daily production capacity of between 50 and 100 units. Additionally, ventilator components have been maximally simplified to develop a more robust, useful, and less complex medical device that facilitates production as well as coupling. The design catalog has been made available with the technical design parameters, material requirements, and printing parameters. Anyone can download the STL files of each validated piece. Companies can freely download the designs and, given that their use is authorized, produce and also distribute them at their own risk.

Today, the consortium is working to obtain an improved model, known as LEITAT 2, modifying the device according to the adjustments required by the AEMPS. Another 3D-printed project to help in the recovery of patients is the multivent splitter, which multiplies access to assisted ventilation equipment. With this equipment, multiple patients with the same ventilation requirements can simultaneously use a single assisted breathing machine in order to save on the number of ventilators used.

The production takes place in the facilities of Consorci de la Zona Franca, Seat, and HP companies. Production will also be supported by Airbus, Navantia, the 3D Incubator, and IAM3DHUB upon their joining the alliance, with the aim of increasing production capacity and the community of users. To illustrate the extent of the collaboration, 3D Incubator currently receives more than 1,000 proposals for 3D printed parts, partnerships, and consultations to help the health care sector. This project is continually growing, with the contributions, knowledge, and resources shared to enhance Spain's economic and social recovery in the face of the COVID-19 crisis and to simultaneously support entrepreneurs and the health care system.

CASE #20 - INNOVATION CENTRE OF DUBAI MUNICIPALITY (UNITED ARAB EMIRATES) - CUTTING CONSTRUCTION COSTS OF PUBLIC BUILDINGS

In Dubai, where the construction sector is estimated to account for roughly 11 percent of GDP, an office has been set up to ensure the implementation of a strategy to increase the share of construction using 3D printing to 25 percent by 2030.[40] An important step in the implementation of this strategy was the unveiling of the largest building in the world built using 3D printing: a two-story administrative building in Warsan, a district in eastern Dubai.

Officials responsible for the project called on

[40] S. Saseendran, "Dubai Opens Largest 3-D Printed Building in Al Warsan," Gulf News, October 23, 2019, https://gulfnews.com/uae/dubai-opens-largest-3-d-printed-building-in-al-warsan-1.67334330.

the services of a company specializing in "building printing": Apis Cor., based in Boston, Massachusetts. Although the lead times were long (a one-year technical study phase was especially critical to test the resistance of the materials to the Emirates' weather conditions), the project would make it possible to reduce the amount of waste by 60 percent compared to the conventional construction process. More generally, the city of Dubai is banking on a sharp reduction in construction costs by implementing this strategy. According to its estimates, 3D printing should eventually reduce labor costs by 60 percent compared to traditional construction methods.[41]

[41] M. Thomsen, "World's Biggest 3D Printed Building Opens in Dubai, a Two-Story 6,900 Square-Foot Government Office That's Part of a Plan to Have 25 Percent of All New Construction Made with 3D Printers by 2030," Daily Mail (UK), February 6, 2020, https://www.dailymail.co.uk/sciencetech/article-7975233/Worlds-biggest-3D-printed-building-opens-Dubai-6-900-square-foot-government-office.html.

VII. CHOOSING A DISRUPTIVE TECHNOLOGY SOLUTION PROVIDER

The following are some basic requirements for the successful acquisition of innovative, technology-intensive solutions:

- Develop upstream exchanges between public authorities and economic operators, in particular to develop a detailed understanding of the technical, economic, and regulatory issues at stake.
- Formulate needs in terms of functionalities and performance rather than solutions.
- Define implementation strategies that are neither too small nor too big.
- Adapt purchasing strategies (division into technical lots, options, form and duration of the contract, etc.).
- Think in terms of TCO over the life cycle, or even in terms of TVO, and define the selection criteria accordingly.
- Facilitate access for SMEs, in particular by defining application criteria that do not exclude them unnecessarily.
- Define bid evaluation criteria that are not only technical but also allow the buyer to assess the vendor's ability to actually deploy its technology.
- Strengthen the clauses and the system for monitoring contractual execution and measuring gains.

Basically, two ways of buying innovation can be distinguished:

- Financing the innovation process and expecting potential results
- Buying new products, services, or processes that are already available for immediate use

In the first case, the public purchaser buys research and development services. It describes its needs and invites companies to develop new solutions based upon DTs. The typical procedure to award the contract will be the "innovation partnership." The contracting authority may decide to set up the innovation partnership, with one partner or several partners conducting separate research and development activities. The partnership should be structured in successive phases following the steps in the research and innovation process, which may include product manufacturing or service provision. The innovation partnership should set intermediate targets to be attained by the partners. Based on those targets, the contracting authority may decide after each phase to terminate the partnership or, in the case of a partnership with several partners, to reduce the number of partners by terminating individual contracts, provided that the contracting authority has indicated in the procurement documents those possibilities and conditions.

In selecting candidates, contracting authorities should, in particular, apply criteria underlining the candidates' capacity to conduct research and development and to develop and implement innovative solutions (cf. DIRECTIVE 2014/24 of the EU on public procurement).

In the second case, the public purchaser acts as an early adopter and purchases a good, service, or process that is reasonably new to the market. Typical procedures to award

the contract will be "competitive dialogue" or the "competitive procedure with negotiation." A contracting authority may open a competitive dialogue with economic operators with a view to identifying and defining the most appropriate means of meeting its needs. It may discuss all aspects of the contract with the companies that were invited to take part in the dialogue. The contracting authority continues the dialogue until it can identify the solution or solutions capable of meeting its needs. If the contracting authority knows that one or more acceptable solutions exist on the market, it launches a fairly classic "competitive procedure with negotiation."

In most cases, a public procurement procedure is conducted in two stages. The first consists of assessing the candidates' capabilities, and the second of evaluating the bids of only those companies (or groups of companies) deemed capable.

At the first stage, the contracting authority may define a minimum qualification requirement below which tenders from companies (or groups of companies) will not be considered. It may also define capacity criteria that will make it possible to restrict the number of candidates authorized to submit a tender (restricted procedure with a short list). This approach of adding capacity criteria to form a short list is most often used for complex projects, as it makes it possible to reduce the workload generated by the dialogue with bidders and to conduct an analysis of their offers. It is particularly suited to DT purchases where significant interaction with bidders is essential to evaluate and optimize supplier offers and finalize the contract. A short list is usually made up of three to five companies or groups of companies.

Minimum qualification requirements ("pass or fail" capacity thresholds) should be defined in such a way that they do not unnecessarily exclude small, innovative enterprises from competition. They should only limit the risks borne by public authorities.

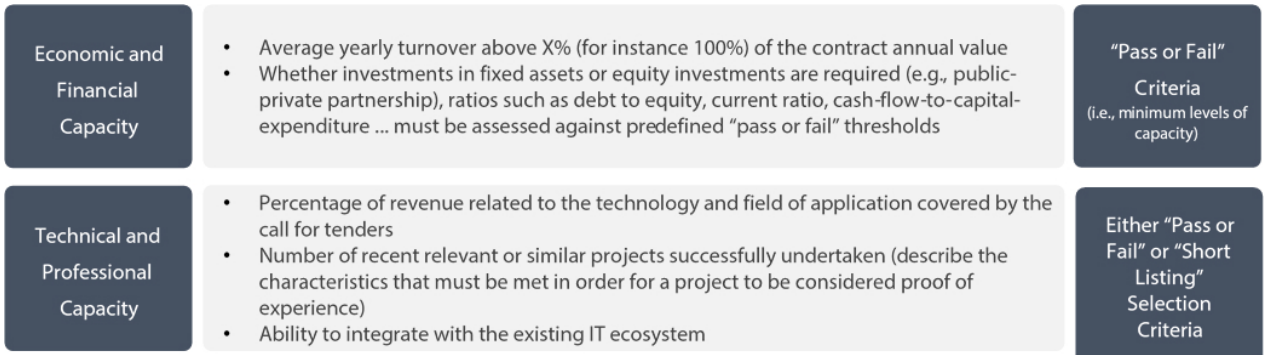
The criteria for compiling the short list must be objective and enforceable. They must make it possible to select only the most qualified companies with which the procuring authority can build the solution best suited to its needs. In other words, they must not lead to the selection of only the biggest companies with the greatest marketing power.

Candidate experience will be assessed in light of the tangible and convincing achievements presented. The references put forward by the candidate must express a real capacity to serve the needs of the public authority, in particular, that they demonstrate knowledge of the context and specificities of the latter.

Candidates' technical capacity will be assessed according to criteria that vary depending on the project and the technology to be implemented. It is recommended that technical capability criteria not be defined in a way that de facto excludes one technological solution or another. Typically, technical interoperability issues should not be approached from the perspective of the partnerships that a particular candidate would have with an existing vendor, but only from the ability to make the technological layers communicate with each other.

The second stage, consisting of the evaluation of tenders, must be carried out

Figure 46. Minimum Capacity Levels



using a technical and financial scoring grid. The scoring criteria are weighted and are themselves broken down into weighted subcriteria. The weight of a criterion or subcriterion expresses the importance that the procuring authority attaches to a particular aspect of the supplier's offer.

The technical criteria used must be as quantifiable as possible and therefore transparent and objective:

- The performance of the technology is evaluated in terms of functional coverage and depth, as well as robustness and scalability.
- The degree of interoperability and openness to other systems (APIs) and data sources is often assessed.
- The methods and deadlines proposed by the candidates are to be considered as they express their mastery of the subject.
- Company commitments in terms of corrective and evolutionary maintenance, as well as managing the end of the contract, must be carefully evaluated as they reduce the risks borne by the contracting authority.

The assessment of the financial offer must be made by taking into account all the costs over the life cycle of the technology (TCO). If, in practice, the implementation of DTs to optimize the purchasing process only very rarely generates direct revenue for the contracting authority, the income generated by the implementation of the DT might also be valuated (TVO).

Figure 47: Evaluation Criteria

Criterion	Subcriteria
Technical/ Quality Evaluation	Evaluation of the technical offer: • Performance of the technology (e.g., functional content and usability of the SaaS application) • Interoperability and openness of the technology • Relevance of the proposed means (including human resources) and methods to implement the technology • Duration of the implementation • Quality and reliability of the proposed maintenance scheme, post-termination assistance services provisions
Financial/Cost Evaluation	Evaluation of the financial offer: • Price of the contract, overall net present value (NPV) in the case of a public-private partnership • Additional costs over the life cycle of the contract (e.g., hosting or maintenance costs) • Revenues that may be generated and shared with the public authority

VIII. VENDORS FOCUSED ON THE PROCUREMENT PROCESS

This nonexhaustive list is meant to guide users and is not meant as a recommendation of any specific tool or vendor. It must be completed with a meticulous sourcing job prior to launching any request for proposals or contracting process, depending on the context and on the buyer's needs.

Figure 48: Detailed List of Vendors

DISRUPTIVE TECHNOLOGY	*MARKET SEGMENT*	LEADERS	CHALLENGERS	COMPLEMENTARY VALUE OFFERING
3D-printing	*Hardware*	**3DSYSTEMS** (www.3dsystems.com) **DESKTOP METAL** (www.desktopmetal.com) **FORMLABS** (formlabs.com) **MAKERBOT** (www.makerbot.com) **STRATASYS** (www.stratasys.com)	**ULTIMAKER** (ultimaker.com) **VOLTERA** (www.voltera.io) **ZORTRAX** (zortrax.com)	**SCULPTEO** (www.sculpteo.com) **SHAPEWAYS** (www.shapeways.com)
GIS & Geotagging	*Software*	**ARCGIS** (www.arcgis.com) **CARTO** (www.carto.com) **MAPBOX** (www.mapbox.com) **MAPINFO** (www.precisely.com) **MAPLINE** (mapline.com)	**BUSINESS GEOGRAPHIC** (business-geographic.com) **CALIPER** (www.caliper.com) **GEOMEDIA** (www.hexagongeospatial.com) **GLOBAL MAPPER** (www.bluemarblegeo.com) **LANDVISION** (www.digmap.com) **SUPERMAP** (www.supermap.com)	**HERE** (www.developer.here.com) **QGIS** (www.qgis.org) **BING MAPS** (www.microsoft.com/maps)
Blockchain	*BaaS*	**HYPERLEDGER GRID** (www.hyperledger.org) **MICROSOFT AZURE** (azure.microsoft.com) **SAP** (www.sap.com) **VECHAIN** (www.vechain.com)	**BLOCKO** (www.blocko.io) **COINFABRIK** (www.coinfabrik.com) **INFOSYS** (www.infosys.com) **PEER LEDGER** (peerledger.com)	**RUBIX CORE** (www2.deloitte.com)

DISRUPTIVE TECHNOLOGY	*MARKET SEGMENT*	LEADERS	CHALLENGERS	COMPLEMENTARY VALUE OFFERING
RPA & AI	*RPA*	**AUTOMATION ANYWHERE** (www.automationanywhere.com) **BLUE PRISM** (www.blueprism.com) **UI PATH** (www.uipath.com) **WORK FUSION** (www.workfusion.com)	**CONTEXTOR** (contextor.eu) **EDGEVERVE** (www.edgeverve.com) **HELP SYSTEMS** (www.helpsystems.com)	**ANTWORKS** (www.ant.works)
	AI solutions	**DATABRICKS** (www.databricks.com) **DATAIKU** (www.dataiku.com) **SAS** (www.sas.com) **ALTERYX** (www.alteryx.com) **MATHWORKS** (www.mathworks.com)	**GOLEM.AI** (www.golem.ai) **SUPLARI** (www.suplari.com)	**AUM BIOSYNC** (aum.bio) **PANGA** (www.panga.fr)
IoT	*Connectivity*	**AERIS** (www.aeris.com) **BICS** (bics.com) **CONNEXA** (www.connexa.com) **INTEL** (www.intel.com) **TERACODE** (www.teracode.com) **SIGFOX** (www.sigfox.com)	**ALLIOT TECHNOLOGIES** (www.alliot.co.uk) **GEMALTO** (www.gemalto.com) **KORE** (www.korewireless.com) **INTEGRON** (www.integron.com)	**MNUBO** (mnubo.com) **SENSORCLOUD** (https://www.sensorcloud.com)
	Applications	**CONNECTED YOU** (connectedyou.io) **SCHNEIDER ELECTRIC** (www.se.com) **SIEMENS** (www.plm.automation.siemens.com) **VERIZON CONNECT** (www.verizonconnect.com) **WORLD SENSING** (www.worldsensing.com)	**1NCE** (1nce.com) **ABB** (new.abb.com) **ADVANCED ENERGY** (www.advancedenergy.com) **SENSEFORCE** (senseforce.io) **SIGHT MACHINE** (sightmachine.com)	**SENSORUP** (sensorup.com) **TACHYUS** (http://www.tachyus.com)
Drones	*Hardware*	**3DR** (www.3dr.com) **DJI** (www.dji.com) **PARROT** (www.parrot.com)	**DELAIR** (delair.aero) **SKYCATCH** (www.skycatch.com) **SKYDIO** (www.skydio.com) **SQUADRONE SYSTEM** (squadrone-system.com) **YUNEEC** (www.yuneec.com)	**DRONE BASE** (dronebase.com) **DRONEDEPLOY** (www.dronedeploy.com)

DISRUPTIVE TECHNOLOGY	*MARKET SEGMENT*	LEADERS	CHALLENGERS	COMPLEMENTARY VALUE OFFERING
CLOUD & XaaS	*SaaS*	**COUPA** (www.coupa.com) **IVALUA** (www.ivalua.com) **SAP ARIBA** (www.ariba.com)	**CORCENTRIC** (www.determine.com) **GEP** (www.gep.com) **JAEGGER** (www.jaegger.com) **SYNERTRADE** (www.synertrade.com) **ZYCUS** (www.zycus.com)	**NEQO** (www.neqo.eu) **SIEVO** (www.sievo.com) **LOKAD** (www.lokad.com)
	PaaS	**BLUELOCK** (www.bluelock.com) **IBM** (www.ibm.com) **GOOGLE COMPUTE ENGINE** (cloud.google.com) **RACKSPACE** (www.rackspace.com)	**FUJITSU** (www.fujitsu.com) **FOREPaaS** (www.forepaas.com) **SAVVIS** (www.savvis.com)	
	IaaS	**AWS** (aws.amazon.com) **MICROSOFT AZUR** (azure.microsoft.com) **GOOGLE** (console.cloud.google.com) **ALIBABA** (eu.alibabacloud.com)	**3DS OUTSCALE** (www.outscale.com) **DELL** (www.delltechnologies.com) **HPE** (www.hpe.com) **OVH** (www.ovhcloud.com)	
BIG DATA & DATA ANALYTICS	*Big Data & Analytics*	**CLIC DATA** (www.clicdata.com) **QLIKVIEW** (www.qlik.com) **SENSEI** (senseiprojectsolutions.com) **SPLUNK** (www.splunk.com) **SQREAM** (www.sqream.com) **TABLEAU** (www.tableau.com) **TALEND** (www.talend.com) **TIBCO** (www.tibco.com) **UMETRICS** (umetrics.com)	**GLASSBEAM** (www.glassbeam.com) **HUAWEI** (e.huawei.com) **SUMO LOGIC** (www.sumologic.com) **UPTAKE** (www.uptake.com)	**GREEN TROPISM** (www.greentropism.com) **PENTAHO** (www.hitachivantara.com)

IX. INTERVIEWS

1. INTERVIEWED CONTACTS

Kay FIRTH-BUTTERFIELD, The World Economic Forum (USA)

Miguel GARCIA-MENENDEZ, Alastria Blockchain Ecosystem (Madrid, SPAIN)

Omid GHAFFARI-TABRIZI, Government Procurement Subject Matter Expert (Washington, DC, USA)

Hunt LA CASCIA, The World Bank (Washington, DC, USA)

Olivier LEFEVRE, NRB (Brussels, BELGIUM)

Miguel LLOP CHABRERA, Fundacion Valenciaport (Valencia, SPAIN)

Bertrand MALTAVERNE, Ivalua (Vienna, AUSTRIA)

Stela MOCAN, The World Bank (Washington, USA)

Albert SANCHEZ-GRAELLS, University of Bristol (Bristol, UK)

Eric TROUSSARD, Sigfox (Toulouse, FRANCE)

2. INTERVIEW GUIDE (QUESTIONNAIRE)

SECTION 0. INFORMATION

Dear Madam / Sir,

The World Bank is doing an analysis on the impact of disruptive technologies on public procurement. The output of the analysis are guidelines to support governments and task teams in designing and implementing public procurement reforms using innovative and disruptive technologies.

The World Bank has selected CKS Consulting (www.cks-consulting.com/en), a multinational consulting company specialized in procurement, as its partner for developing these guidelines.

Based on your activities and broad, global vision of the use of disruptive technologies, the World Bank team has identified your organization as a potential contributor to research efforts. To this end, would you be available for a 30-45 minute consultation on the subject?

Best regards,
The World Bank

SECTION 1. DTS TODAY

Please briefly introduce yourself, your position and your professional path in the area of disruptive technologies (DTs).

Please list the top three DTs that you believe can be game changers for public procurement in the next decade. What adoption drivers would you identify?

SECTION 2. SCORECARD & ADOPTION FORCES

- Which technology are we discussing?
- In what perspective is this technology a disruptive one for economic actors today?
- Are we discussing upstream or downstream?
- Can it improve the quality of the civil works, goods or services to be procured? How / Why?
- What direct impact can it have on the acquisition and operational cost?
- How can it improve the delivery lead-time?
- What productivity benefits do you identify (efficiency and process-redesign)?
- How can it improve transparency of the procurement process?
- How can it secure public trust in the integrity of public procurement (e.g., equality of treatment…)?
- How can it support countries achieve their economic development objectives?
- How can it support countries achieve their sustainable development objectives?
- What are the key points to have in mind in order to secure change management success?
- Could the introduction of this DT in PP generate (unforeseen) negative externalities?
- Some countries may have regulatory barriers that prevent DT implementation. Would you recommend a sovereign, national technology to be developed vs. imported technology?
- Are there reasonably important negative impacts due to low maturity of this DT?
- What is the business model of this DT's promoters?
- What are the criteria countries need to use in order to select a DT vendor?
- From a cost perspective (CAPEX / OPEX) is this DT sustainable on the long run for developing countries?
- What is the typical payback horizon of this technology?
- What is the typical payback horizon of this technology?
- Which mix of DTs would you recommend to FCV?
- Which mix of DTs would you recommend to LIC?
- Which mix of DTs would you recommend to MIC?
- Which mix of DTs would you recommend to HIC?

SECTION 3. USE CASE

- Public authority
- Disruptive technology
- Disruptive technology provider
- Project basics & scope
- Project timeline, benefits and budget vs. payback
- Key success factors
- Main risks & roadblocks

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